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THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK

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PROCEDINGS OF THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.

BELIEVING THAT THIS SOCIETY FAVORS PROGRESS IN LITERARY AS WELL AS IN ENGINEERING MATTERS, THIS PUBLICATION HAS BEEN PRINTED IN ACCORDANCE WITH THE RECOMMENDATIONS OF THE SIMPLIFIED SPELLING BOARD.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 30.

PRESENTED FEBRUARY 27TH, 1907.

CONSTRUCTION DETAILS OF REINFORCED CONCRETE WORK.

BY MR. DE FOREST H. DIXON.*

WITH DISCUSSION BY
RUDOLPH P. MILLER, GEORGE W. TILLSON, GEORGE S. RICE, SVERRE DAHM, GEORGE L. CHRISTIAN, AND THE AUTHOR.

It is the intention of the author, in the present paper, to present a description of certain methods and details used in reinforced concrete work, and to point out, in so far as he is able, their value in securing safe and economical construction.

Before proceding, however, with those matters forming the proper subject of his remarks, he feels that recent events make it desirable that a few words be said upon the subject of the general design and preparation for such work. The safety of any piece of engineering work is dependent, primarily, upon its correct general design, and by correct general design is here meant that the loads to be carried by the structure are properly computed, and that the beams, colums, and other portions of the structure are then figured in accordance with such loads, allowing a proper factor of safety to cover defects in construction and possible overloading. Perhaps all of us present have been imprest by the very uncertain behavior of reinforced concrete floors, as described in recent numbers of our engineering press. On one page we read a description of a test on some floor, which test shows a load of three times the assumed live load, carried on spans of 16 ft., with a deflection of

* General Superintendent, Turner Construction Company.

about ⅛ in. Turning over a few pages, our eye is met by fotografs which might be supposed to represent the devastation caused by earthquake shocks, were it not that the accompanying text informs us that they show the result of removing the forms from under one of the upper floors of some bilding, after the concrete forming such floor had been in place three or four weeks. We are informed that the floor in question fell under its own weight, and that, in falling, it carried much below with it. On reading such a description, the natural opinion formed is that exceedingly poor materials were used or careless work was done, and such an opinion is only too often justified by the facts; but the speaker, knowing how much abuse reinforced concrete will stand without failing, is impelled to inquire if possibly there are not other causes partially responsible for these failures, in addition to poor materials and bad work. Such inquiry leads him to the belief that, in many cases, either thru ignorance or desire to do cheap work, the factor of safety used in design, is so juggled as to be greatly diminisht, thus inviting disaster. With a factor of safety partly done away with, before the actual work of construction is begun, it is evident that poor workmanship, which, with a proper safety factor, would pass unnoticed, will lead to failure. That the condition stated is not imaginary by any means, may be shown by quoting from a letter recently publisht, in which an engineer explains the partial failure of some roof beams designed by him, as follows:

"The bilding was originally designed to be of 12-in. brick walls, flimsy iron trusses, and corrugated iron roof, and the owner made a demand upon me to design a bilding to come within the price of the above construction, and I, therefore, assumed a factor of safety of about two, in the construction, temperature stresses being considered."

Now, I do not know how often an examination of floors that have failed, would reveal a factor of safety of about two, used in design; but it is my belief that such would be the case more often than might be supposed. I do know that a floor is sometimes said to be figured with a factor of safety of four, when it is designed to fail under its dead load plus four times the assumed live load, instead of under four times the sum of its live and dead loads, as should be understood when factor of safety of a floor is given.

PLATE 1.
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DIXON ON CONSTRUCTION DETAILS
OF REINFORCED CONCRETE WORK.

FIG. 1.—CONCRETING A REINFORCED CONCRETE FLOOR, SHOWING THE STEEL REINFORCEMENT IN PLACE, TOOLS USED, ETC.

FIG. 2.—SHOWING FORMS USED FOR WALLS, ETC.

How great the difference is between these two definitions of factor of safety, can be shown by taking a floor designed for a live load of 75 lb. per sq. ft. This floor will probably weigh about 75 lb. per sq. ft., which is the dead load. Using one definition of factor of safety, and assuming said safety factor to be four, this floor would be designed to fail under a total load of 375 lb. per sq. ft. Under the other definition, it would be designed to carry a total load of 600 lb. per sq. ft.

The author has heard of various other liberties having been taken with the factor of safety, and he feels that the time has about come when we must ask that concrete construction be given a fair chance, for it certainly is not getting it now, and the first step in that direction is going to be to get those in charge of bildings to assure themselves that the design is correct and ample. Perhaps I have dwelt upon this point of skimping the design at too great length, as here, in New York, the tendency to skimp is not apparent, owing to the existence of a vigilant bilding department, which, if I may be pardoned for saying so, leans toward the side of too heavy, rather than too light design, and leans pretty hard at that. But what has been said helps in part to explain a good many failures. I say in part, because the immediate and most prominent cause is almost invariably poor material or poor workmanship. These defects it is our intention to discuss at some length, but before doing so you must pardon a few words on the question of plans, for, unless proper plans are furnisht to the superintendent in charge of the work, his attention, instead of being concentrated on the securing of the best and most economical ways of handling his work, will be necessarily diverted. He will have to supply such data as his plans lack. In some quarters, there appears to be the impression that very meager plans will serve for reinforced concrete work. This is not the case, and, as a matter of fact, the drawings required for a reinforced concrete bilding are almost as extensiv as those required for a bilding carried by structural steel. The importance of such aid, as complete plans and correctly prepared schedules of steel bars, windows, doors, etc., give towards the securing of good, rapid and economical work, cannot be overestimated.

Assuming, now, that our Superintendent in charge of the work

has been furnisht with such detailed plans as we have described, let us examine the questions which confront him in his efforts to secure, in the structure, the full strength possible, under the plans given him. It is to be noted first that he himself should necessarily understand the intent and purpose of the design in order that he may effectivly execute the same, or, in other words, that he be able to appreciate the fact that, if the floor slab is figured as part of the compression member of a beam, he is required to place the beam and slab at one time, or if, for any reason, this is impossible, then he must provide sufficient steel bonding between the beam and the slab to take up the horizontal shear. Many other questions arise that require engineering judgment, and while exceptions may in extreme cases be made, it is certainly advisable that the Superintendent in charge of any piece of reinforced concrete work be an Engineer; or that, if the Superintendent be not an Engineer, that one of his assistants shall have had such training. As to the character of the men comprizing the organization at the command of our Superintendent, it is also desirable that the steel foreman be a graduate of an engineering school. This is desirable, not only because he will then appreciate the reason for the work which is under his control, but also because his education fits him to readily read complicated plans and schedules. A company will find one of its best training schools for future superintendents in the position of steel foremen. The concrete foreman must be a thoroly trustworthy man, and one who will do as he is told even tho he may consider the instructions given him as foolish and unnecessary. The foreman who applies for a position, and couples with his application a statement that he has been engaged in fireproofing and sidewalk work for the past fifteen years, and hence knows concrete from A to Z, is usually, tho not always, a poor man to select, for the reason that he has been putting in concrete under conditions where a poor mixture has answered all visible and immediate requirements, and he has it firmly imbedded in his mind that the grade of work he has been turning out is sufficiently good, and, that when a better grade of work is insisted upon, it is because of the whim of the man making such demand. To use an old frase, "It is hard to teach an old dog new tricks." These remarks upon the subject of organization have been made because

the speaker believes that the attempt to rapidly carry on large constructions in reinforced concrete, with an organization not thoroly trained and possessing engineering judgment, invites failure.

Taking up now various points that require attention on the bilding, we come, first, to the question of the proper inspection of the materials used.

Inspection of Material.

The most important materials used are cement, sand, gravel or stone, and steel. As to all but the latter, New York occupies an almost unique position, and it is doutful if any other place in the country is so favored as regards the material required to make good concrete. Long Iland is one inexhaustible sand and gravel bank of the best quality, while the Hudson gives us trap which is perfection itself. Owing to an extensiv waterfront, these materials can nearly always be delivered on scows near the work. How fortunate we are in this respect cannot be appreciated, until one has seen the quality of sand and stone used in other less fortunate regions, and often used willingly, because the inhabitants of those regions have never seen anything better.

Cement, if of an old and establisht brand, is very unlikely to be poor, but, on extensiv work, arrangements may be made to have the cement tested at the mill before shipment. Reliable testing laboratories having offices in the mill district will sample cars as loaded, seal them, and will then forward the results of soundness and seven-day tests by mail, so that they will arrive on the job before the cement is received.

Sand.—It is very important that the sand be clean and sharp. Place little confidence in statements publisht not long since, in the engineering press, to the effect that clay, to a very considerable extent, does not injure sand. Note that the clay used in these tests was ground as a dry powder, and then mixt with the sand. In nature, clay occurs as a slimy lubricant, and even a comparativly small amount of it will have a markt effect, especially upon the time required for the concrete to set and gain even partial strength. If the sand is to come from a local bank, make sure that the bank is properly stript, or, better yet, have the sand delivered ahead, and inspect it before using. Finally, if there is

any question as to its fitness, have it tested, in a one-to-three mixture. The cost of doing this is small, but the information obtained is valuable.

Gravel.—Good gravel gives equal strength with stone for use in beams and floor slabs. It makes a concrete easy to work in to difficult positions, and is to be preferred for many kinds of work. As with sand, examin gravel carefully to make sure that it is not covered with a slime of clay.

Broken Stone.—The commercial ¾-in. size is best suited for most reinforced work. Clean stone dust is not injurious, if its presence is taken into account in proportioning the amount of sand used; but watch for the presence of dirt instead of dust, as considerable dirt may sometimes be present if the quarry from which the stone comes has a seamy formation.

Steel.—The inspection of the steel used is, perhaps, of more importance than might at first be assumed, for the impression prevails that steel, as manufactured at the present time, is a uniform product, and experience confirms this impression in so far as the product of some mills is concerned, but the product of those small mills that roll from old rails and scrap requires very careful inspection. This is especially true if a high carbon steel is employed.

As to the use of plain bars, or so-called mechanical bond bars, the author is strongly in favor of using bars possessing a mechanical bond. Aside from the usual reasons given for this preference, with which all are probably familiar, he believes that, with a plain bar, there is a very real danger—that the bond between the concrete and the steel will be broken either by wheeling over the floor before the concrete has gained its strength, or by the removal of the forms from under a floor before the concrete has attained its full strength. As a practical point, he douts very much if plain bars left projecting from one body of concrete, for the purpose of bonding it to an adjoining portion of the structure, serve in full measure the purpose for which they are intended, because such projecting bars are often hit, thus loosening their hold on the concrete.

Forms.

We are interested in this part of the work because of the fact that the success or failure of a job, as a money making proposition,

FIG 1.—PLATE SHOWING VARIOUS STEPS IN BILDING A REINFORCED CONCRETE FENCE.

FIG. 2.—FORM USED FOR BILDING CORNICE.

is largely dependent upon the way in which the form work is handled. Speaking roughly, the labor item on the forms required for a floor, is greater than the cost item for all the concrete, steel and finish labor, required to complete the floor. In the form work, the lumber item, while large, is overshadowed by the labor charge. In the items of concrete, steel and finish, the cost of material is the predominating factor. It is seldom that serious errors are made in estimating the cost of material. Far more often, if there be an error, it is in estimating the labor item, and as the carpenter labor on an entire bilding just about equals all the rest of the labor required on that bilding, it is evident that a designer, having a proper knowledge of this condition, will use every care to so design his work, as to reduce the labor item on forms to a minimum. He will keep constantly before his mind the fact that economy in form work is obtained by the repeated use of the same panel or mold; hence he will do some careful figuring before making the beam lay-out on different floors dissimilar—even tho, at first thought, a saving may seem to be effected by so doing. In the designing of ornamentations, it is desirable to repeat the same form wherever possible. If the forms are to be made of wood, warped surfaces must, of course, be avoided. In constructing belt courses, and other ornamental details, it is usually best to omit these features at the time of carrying out the main structure; providing, however, recesses and bond bars in the proper places. Doing this, makes it possible to bild belt courses, corbels, etc., later at a convenient season, yet without interfering with the time of the completion of the bilding, and admits of using one form which is moved from one point to another. The subject of form work is complicated by so many considerations, that no attempt will be made here to go into further details, except to call your attention to the additional cost which is occasioned by so designing the front of a bilding as to require the wall construction to be carried past the floor level, as a monolith, or in other words, by failing to provide a break of some kind, in the construction, at the floor levels.

Of course, the author understands that, oftentimes, the architectural effect must outweigh matters of cost, and has no intention of advancing this point as a criticism of work that has been done.

Placing Steel Reinforcements.

The aim to be attained under this heading, is that the steel reinforcement shall be placed as shown on the plans, and, further, that it shall be so placed as to remain in its proper position during concreting. As the steel is entirely imbedded in the concrete, there is no means of knowing, after the concrete is once in place, whether the steel is in proper position or not—hence, it becomes important to carefully inspect all steel in place before concreting is begun. To admit of this inspection, steel for a day's work should be placed in advance of the concrete. It then becomes an easy matter for the Superintendent to look it over and make sure that it is in place as required. The methods of holding the bars in position may be described better later on, with the aid of fotografs. Your attention is called to the large gain in strength secured by bending up beam bars at their ends. A beam having its steel reinforcement so bent up, is about 40% stronger than one having the same amount of steel placed in the bottom of the beam thruout its length. This gain of 40% is entirely independent of continuous action, for the experiments upon which this percentage is based were made upon test beams which were entirely free at their ends. The reason for this increase in strength, even with free ends, is probably due, in part, to the strengthening of the beam near its ends, against diagonal tension; but the truss action of the bent rods probably also plays an important part.

In designing reinforcement, it is important to remember that two bodies cannot occupy the same space, at the same time. This fact would seem self-evident, but the speaker has seen a great deal of trouble and expense caused by the designer laying out his reinforcement so that bars in the beams, girders and colums, would interfere, thus making it difficult to place the steel in the best manner. The requirement of the New York Department that beams be designed as free ended, should not prevent care being taken to secure the advantages of continuous action, by lapping girder and beam steel at the ends. Where new portions of a bilding are to be connected to parts already in place, care should be taken while bilding the first portion to leave bond bars projecting. It is to be constantly kept in mind that one of the chief and unique elements of strength, in reinforced concrete, is its monolithic

character, and while it is impossible, and, also, inadvisable, to place all the concrete in a large structure at one time, it should be our constant aim to so place our steel as to maintain, as far as possible, the monolithic character of the work.

Colums are now almost universally reinforced with spiral hooping. In addition to this spiral reinforcement, vertical rods connected by threaded couplings should be used in the colums of bildings which are to be subjected to heavy vibration. In designing colum reinforcement, care must be taken to avoid such an arrangement of the steel as will make it difficult to work the concrete thoroly into place. With the use of spiral reinforcement and vertical rods, as described, no trouble need be apprehended, because the entire colum is open, and the concrete may be thoroly spaded. The author has heard of one case where a complicated system of colum reinforcement was used, involving a number of ties between the vertical bars. The result of thus obstructing the interior of the colum was that, upon removing the forms from one colum, it was found that the concrete, perhaps being a little too dry, had archt, and that the colum contained a cavity nearly large enough to accommodate a good sized boy. The statement is often made—"The detail is all right—the trouble is with its careless execution." This is very true, but what I am trying to impress upon you is the importance of making details simple and practicable, and then insisting that they be carried out.

Placing Concrete.

The concrete for reinforced work should always be what is known as a "wet mix." Under no circumstances, should a dry mix be allowed, as with too little water it is impossible to properly work the concrete around the reinforcement, and there is the gravest danger that the concrete will arch over points where the steel reinforcement forms a network, as, for example, where the beam and girder steel comes together over a colum. The author considers that the best way to determin whether or not the concrete be wet enough, is to watch the filling of the beams. When dumpt into a beam, the consistency should be such that, upon tapping the bottom of the beam form or the steel reinforcement, in advance of the concrete, the concrete will flow along the beam

assuming an angle of about 10 to 15°, with the horizontal. It is, perhaps, not desirable that it be so wet that water will separate from the concrete to any extent, and flow in advance of the concrete, but it is always better to have too much rather than too little water. In placing concrete, jar the metal reinforcement in advance of the concrete, as this jarring assures the proper coating of the bar with mortar.

Next to the wetness of mix, neatness should be insisted upon. Every day's work should be boxt in, and the end of a day's work should be against vertical stoppers of wood placed in the middle of the beams, and across the slab. These stoppers have holes bored in them, thru which the reinforcing rods project. In the author's opinion, the use of such stoppers, while adding somewhat to the expense, is very essential. The sloping off of concrete in the beams and girders should never be allowed. It is a well-known fact that there is almost no bond between old and new concrete. This being the case, it is evident that, to leave a long fin of concrete in the bottom of a beam, at the end of a day's work, is inviting this fin to scale off within a very few minutes of the time when a fire hits it.

With a wet mix, concrete is its own best inspector, for when the forms are removed, any carelessness is at once apparent. If rough spots occur, they should be at once pointed out to the concrete foreman, and he, in time, should come to feel that, having his work show up rough, is little less than a crime.

The bottom of colum forms should be carefully inspected before the concrete is placed, to make sure that all dirt has been removed. To facilitate this inspection, a portion of the colum form on one side, and at the bottom, should be made separate, and one man should be given the duty of cleaning the colum and replacing this movable portion of the form immediately before concreting. In filling basement colums, it is, of course, necessary that ground water be kept below the top of the footing at the time concrete is placed, for, if the concrete be dumpt into even a few inches of water, the cement will separate out, and the lower couple of feet of the colum will consist of gravel and sand alone.

In concreting walls, the end of every day's work should be made to come at some break in the surface, as at the side of a pilaster. If the wall is without projections, then the jointing should be

PLATE 3.
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FIG. 1.—GENERAL VIEW OF REINFORCED CONCRETE BILDING WITH BRICK CURTAIN WALLS.

FIG. 2.—EXAMPLE OF "TOOLED" CONCRETE SURFACE

markt with a V-shaped strip, both horizontally and vertically. If this is impossible, which is seldom the case, then the juncture between old and new work should be made a perfectly straight line. If the surface is to be tooled, every separate area must be monolithic. This is a point often overlookt. Steel reinforcement should be placed around all openings to prevent the tendency to crack at the corners, and the juncture between a light and heavy section must be reinforced with steel well distributed.

Granolithic Finish.

Granolithic finish should be placed monolithic with the slab, or, if placed afterwards, which is desirable in stables and some other classes of work, its thickness should never be less than 1½ in. Recently, an acid solution has been placed on the market which the author has tried in several instances, using, in some cases, finish as thin as ½ in., put on concrete that had attained an age of several months. This finish has been in place for three months, and thus far shows a perfect bond. If further tests confirm these conclusions, then one cause of worry in our work is partially removed, for the sudden thunderstorm, at three in the afternoon, will lose part of its terror.

Time does not permit of going into further details, tho many of them, such as exterior finish, etc., are very important, for the author must confess that he is here tonight more to receive than to give information. He knows that his audience contains members of all branches of the service, and in their varied experience he feels certain that many of those present can give valuable advice to help in the securing of the result we seek to attain, which is strength, economy and speed, all at the same time.

In closing, he wishes to call your attention to the easy attainment of the points he has outlined:

1st. Good and complete plans.

2d. Good organization—a matter of time, it is true; but coming to the final analysis of the cause of failures in reinforced concrete, we often find a new company trying to do too much work at the start, unmindful of the fact that it takes time to train men to properly perform new duties, and that to

send an untried man hundreds of miles from home, to assume charge of work about which he really knows nothing, is not only inviting, but almost compelling failure.

3d. Good materials—and it is easy to avoid mistakes here, if it is remembered that tests on such materials are not made merely for the purpose of recording them in big books on learned subjects.

4th. Steel held in its proper position—and the placing of steel reinforcement before the concreting of a day's work is begun, makes this matter easy.

5th. Good concrete—and a wet mix and monolithic work are here about all that are required to insure the result.

All of these factors are surely easy of achievement, and almost any one, or even two, of them, may be considerably neglected, and still the result will not be bad enough to weaken the construction to any serious extent. Please do not draw the conclusion that the purpose of my remarks tonight has been to show how difficult it is to obtain good steel concrete work. My aim has been, rather, to point out how easy it is to do good work, and do it cheaply, for, with a proper plant and organization, good work is just as cheap as poor. The vicissitudes thru which steel concrete is passing, are, no dout, to be expected when its rapid expansion is considered, but the accounts of recent failures have made sad reading for the author, and he hopes that, before long, the public will awaken to the fact that steel concrete construction is a business requiring experience and will insist that it be handled with some regard to the elementary principles of mechanics and common sense.

DISCUSSION.

Mr. Rudolph P. Miller.—I think the few slides I pickt up as I came over here this evening will serve to corroborate some of the statements Mr. Dixon made in his excellent paper. I never heard a fuller or better statement of the importance of good design, good workmanship and good materials in reinforced concrete construction than tonight.

I am going a little further than Mr. Dixon has in the matter of the placing of the reinforcing steel. You can realize the importance of the position of the steel in the girder. A shifting of that steel upward means a very material weakening of the beam, while a shifting of the reinforcement downward may mean a strengthening of the beam, but at the same time an exposure of the reinforcement. I have had occasion to examin a large bilding recently in which nearly all of the principles laid down by Mr. Dixon were violated, with the result that some of the steel was badly exposed and very poor results were obtained, to such an extent that a portion of the bilding was condemned and had to be taken down and rebilt.

The point I want to make here is that the steel reinforcement, before being put in position, should be thoroly tied together, so that when placed and then subjected to the pouring of the concrete in the forms, there will be no possibility of the steel shifting and taking a position different than that intended.

The fabrication or assembling of the steel is done at the shops and markt much in the same way that our steel beams in steel structures are markt, so that when it gets to the job, the foreman knows by the number or mark exactly in what part of the form to place it. Then when once placed, the inspection on the part of the superintendent becomes a very simple matter.

Some of our reinforced concrete concerns draw up details for the steel reinforcement before it is fabricated. The detail drawing, which corresponds to a detail drawing for steel work, is prepared in the Engineer's office and sent to the shop. From this, all the details and exact measurements being given, the workmen make up the unit frame, as it is called, and that, when fabricated, is then sent to the job.

I do not want to advocate any one particular form, but I do believe this general principle is the correct one, of fabricating the steel and sending it to the job.

In one method there is a socket which holds the steel reinforcement at its proper distance from the bottom of the form and, at the same time, the bolt entering into that holds it down so that there is no possibility of its moving upward. There is another

advantage claimed for this particular detail, that on the removal of the forms, there remains in the concrete a socket with a screw thread in it, to which pulley hangers or other devices that may be desired, can be attacht.

In the McGraw Bilding on Thirty-ninth Street, the main colum loads are taken by the steel shapes and are helpt out to some extent by the concrete filled in inside the shapes. The concrete outside of the steel shapes is considered only as fireproofing and is not considered as taking any of the load. The point to be noted in this case is that the reinforcing rods are secured in place so there can be no shifting. Attention is also called to the fact that the steel is so placed that a continuous action over the supports is obtained, a desideratum that was pointed out by Mr. Dixon.

A type of unit frame construction with attacht stirrups is often used. When sent from the shop the reinforcing rods and stirrups are flattened out so as to take up as little room as possible. When the frames reach the job the stirrups are drawn up to their proper positions. Then the upper rods are placed on, which with the rods running across give a continuous tie over the supports.

Mr. Dixon has spoken of some colum construction in which the vertical reinforcing rods were tied together to such an extent as to prevent the concrete from getting into the lower part of the forms. An example of this came to my notice recently showing that very trouble when the forms were removed. The condition that was seen was very bad, precaution not having been taken to avoid unnecessary ties; they were more numerous than was necessary and not sufficient account was taken of them. Furthermore, in this particular instance, too large stone was used in the concrete. When the concrete reacht the horizontal ties the stone caught there and the mortar could not get thru between the stone.

Mr. Dixon told of a cast-iron colum with an open head thru which the reinforcing rods were made to pass to secure continuous construction. The case to which he referred was not the first one in the City. In the first concrete bilding erected in Manhattan, at Christopher and Gay Streets in 1902, that principle was carried out.

MR. GEORGE W. TILLSON.—I have a slide that I would like to show, altho it is, unfortunately, more in the nature of a picture than anything else. I hoped and expected, until I was on my way over here, to have enough views of this work to show the details of construction. We had a complete set of fotografs and slides made of this bridge during construction, which showed the details very well, but I found, on making inquiries, that they had been either mislaid or lost. This bridge was probably the first large piece of

PLATE 4.
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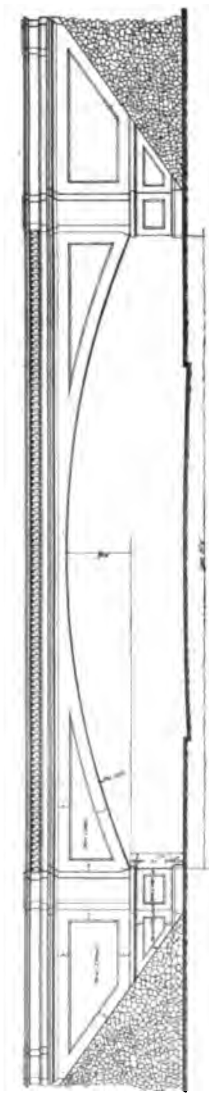
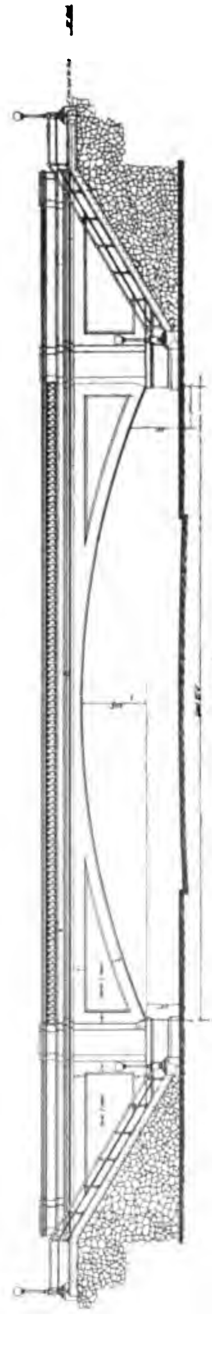


Elevation South Face



Elevation North Face

PLATE SHOWING PROSPECT AVENUE BRIDGE.

reinforced concrete work in bridges that was bilt in New York City. It was designed by Mr. E. J. Fort,* who was then Assistant Engineer in the Bureau of Highways in Brooklyn, and has a clear span of 85 ft.; the total length being about 125 ft. The reason for constructing the bridge was the fact that the bridge itself is parallel to a high bank on quite a steep slope, and Prospect Avenue, coming from Coney Iland, runs at right angles to this slope to South Brooklyn.

There is a great deal of heavy traffic on the street, and in order to get a workable grade it was necessary to put the grade of the avenue considerably below Seeley Street, so much below that it was deemed better to carry Seeley Street over Prospect Avenue rather than to bring its grade down to meet that of Prospect Avenue. Seeley Street is 60 ft. wide and the bridge was constructed for its full width with the exception of a width for the staircase, so as to keep the whole structure within the width of the street. The roadway is carried continuously across the bridge with the roadway of the street itself and paved with asphalt, with which also the street is paved, so that you get a continuous roadway of asphalt. The railing is made of newel posts, altho in this plate it appears more or less continuous, and the whole structure is of concrete and makes a very beautiful appearance on the ground.

In constructing that bridge, we recognized the necessity of having monolithic construction, so that when work on the arch was begun it was continued until it was completed. It required, as the contractors did not have a very large force, about ten days' work.

Plate 4 shows the bridge on the upper side, where the sidewalk is constructed. We have what is intended to be quite an ornamental stairway. There are two bronze posts with electric lights at the top and bottom of the stairs. The railings of the stairs are bronze and very handsome. The bridge is not in a very fashionable locality and 24 hours after the first globe was put up the boys in that vicinity broke it and we put up more, but those did not last much longer, and finally bronze gratings were made to cover the globes. These, however, only lasted a week or two when they were knockt to pieces. Then I decided that such ornamental work was a little too much in advance of the community and we would wait before placing any more.

The bridge, as I said, was practically 60 ft. wide, 125 ft. long, and the contract price was $21 800. We were very fortunate in having a contractor who had no desire to do cheap work and I think the work was very satisfactorily done. There was one peculiar thing about it; the arch and most of the work was completed

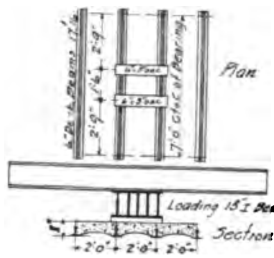
in the fall and the weather became too cold to entirely finish it, so that all of the false work under the arch was left until spring. It was very heavy and, when bilt, it was put up with the idea of knocking out the wedges under the posts in order to take down the frame work. In the spring, however, after the bridge had entirely set, the contractor went to remove the frame work; it was so loose that it was taken down without any trouble at all.

Before closing, I desire to express my appreciation of the paper read here this evening. One seldom hears an engineering paper of such practical value as this one has been, because it has been just what its title says—"Details of Construction." I presume there is no question that in reinforced concrete construction, the carrying out of the details is more important than in almost any other kind of work, and if I were to undertake reinforced concrete construction, I should desire every one connected therewith to fully understand the contents of this paper.

MR. GEORGE S. RICE.—As you gentlemen know, the Rapid Transit construction work contains a very large amount of reinforced concrete and Mr. Dixon's Company did almost all the work in connection with the stairways in the stations. In 1901 it was realized that there were some points in the design involved by the use of the reinforced concrete, which were wanting and very careful experiments were made by the Engineers of the Commission at Columbia University. Mr. Sverre Dahm, now in charge of the designing of Rapid Transit work, was concerned in those experiments and I think he will have a few remarks to make.

MR. SVERRE DAHM.—It may be of interest to the members of this Society to learn about the results of some tests of concrete and reinforced concrete made by the Rapid Transit Railroad Commission.

The first tests, which were very crude, were made in October, 1901. They consisted of comparativ bending tests of deck beams with concrete arches between them, and deck beams without arches. It was found that the beams with concrete arches supported a center load more than 75% heavier than the beams without the arches. This result called for additional tests on a more scientific basis and with more accurate observations. These were undertaken at the time the Commission modified its design from a steel beam construction for its subways to a reinforced concrete design, and they were primarily undertaken to verify the safety of the usually adopted working stresses for reinforced concrete construction. The tests were made in the laboratory of Columbia University and comprized compression tests for concrete blocks and pulling tests for steel rods partially buried in concrete to establish the adhesion and friction between steel and concrete, and bending tests of reinforced concrete beams.

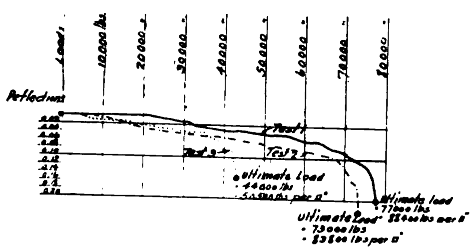


Test 1 Oct. 19th 1901 Deck Beams with arches of concrete 6 weeks old mixed in proportion 1x2x4
Arch 1 mixed very dry cracked but did not break
" 2 " medium dry cracked only a little
" 3 " very wet broken to pieces

Test 2 Oct. 23rd 1901 Deck Beams with arches of concrete 6 weeks old mixed medium dry for all
arch 1. proportion 1x3x5 broken to pieces
arch 2. " " " " "
arch 3. " 1x4x7 Cracked only a little

Test 3. Nov. 14th 1901 Deck Beams without concrete arches

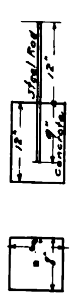
FIG. 1.



Bending Tests of 6" Deck Beams 17 1/4
7'0" Span C to C of Supports
Total Load applied at 2 points 1'6"
apart symmetrical to Center Line

FIG. 2.

Tests on Adhesion between Concrete and Steel made at Columbia University May 9th to July 8th 1903



KIND	AGE	TOTAL LOAD	Adhesion per □"	Remarks	
3/4" sq. Rod Rusted	1 Mo.	11800#	437		
7/8" " " Clean	"	9260#	294		
3/4" " " Red Lead	"	1700#	63		
3/4" " " oil	"	900#	33		
3/4" Twisted Rod clean	25 Days	13550#	500	First drop at 9000#	Block Split
7/8" sq. Rod "	1 Mo.	4610#	146	30 Days in water	
7/8" Thacher Rod "	"	17150#	700	First drop at 13910#	Block Split
3/4" sq. Rod Graphite	"	270#	10		
7/8" Thacher Rod clean	"	19450#	788	Block Split	
3/4" Twisted " "	25 Days	14030#	520	First drop at 6470#	Block Split
3/4" sq. Rod Graphite	1 Mo.	650#	24		
7/8" Thacher Rod Clean	"	11120#	450	These specimens	Blocks split
" " " "	"	10200#	410	were made up in June	
3/4" Twisted " "	"	12330#	457	while the other were	
" " " "	"	15190#	560	made up in April	
3/4" sq. Rod Rusted	3 Mos.	17350#	642	Block Split	
7/8" " " Clean	"	13590#	431	" "	
3/4" " " Red Lead	"	3460#	128		
3/4" " " oil	"	1700#	63		

FIG. 3.

Summary of Compression Tests on Concrete Blocks.
made at Columbia University May and July 1903

Block 6"·6"·6" Concrete 1·2·4

Block No	Kind	Ultimate Total 1 Mo.	Ultimate Total 3 Mos	Ultimate Per Sq. In. 1 Mo	Ultimate Per Sq. In. 3 Mos	1st Crack Load 1 Mo	1st Crack Load 3 Mos	1st Crack Compression 1 Mo	1st Crack Compression 3 Mos	1st Crack Per. Set 1 Mo.	1st Crack Per. Set 3 Mos
1	Gravel	63100#		1753#		56000#		.076"			
2	"	65900#		1830#		46000#		.046"			
3	"		84500#		2350#		68000#		.064"		.030"
4	Gneiss	62100#		1725#		48000#		.079"			
5	"	74600#		2072#		62000#		.066"		.044"	
6	"	67700#		1880#		50000#		.041"			
7	Gneiss Rock and Stone Dust Mortar	35000#		972#		30000#		.043"			
8	"	33300#		925#		30000#		.043"			
9	"		55300#		1540#		46000#		.034"		.022"
10	Limestone	89900#		2500#		70000#		.089"			
11	"		119000#		3300#		84800#		.042"		.033"
12	"	101800#		2830#		66000#		.075"			
13	Gravel (Retempered 24 Hrs)	70800#		1970#		62000#		.041"			
14	" 48 "	33020#		914#		32000#		.041"		.027"	
15	Gravel	69320#		1925#		65000#		.049"		.032"	

FIG. 1.

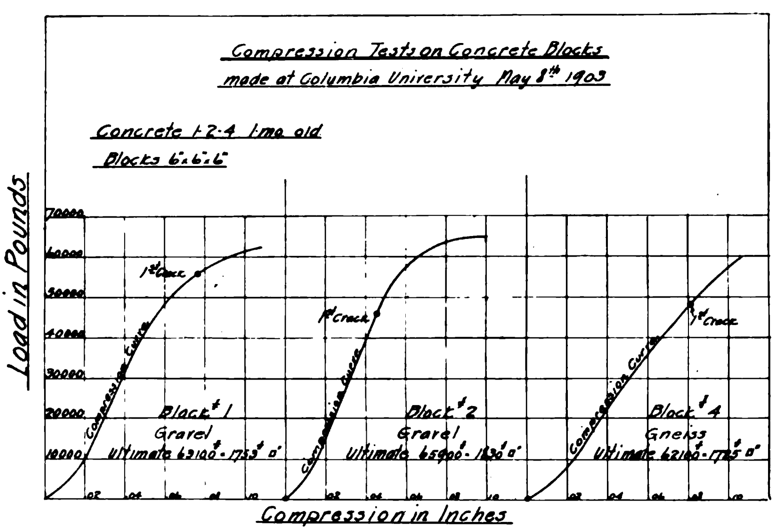


FIG. 2.

PLATE 7.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DIXON ON CONSTRUCTION DETAILS
OF REINFORCED CONCRETE WORK.
DISCUSSION BY S. DAHM.

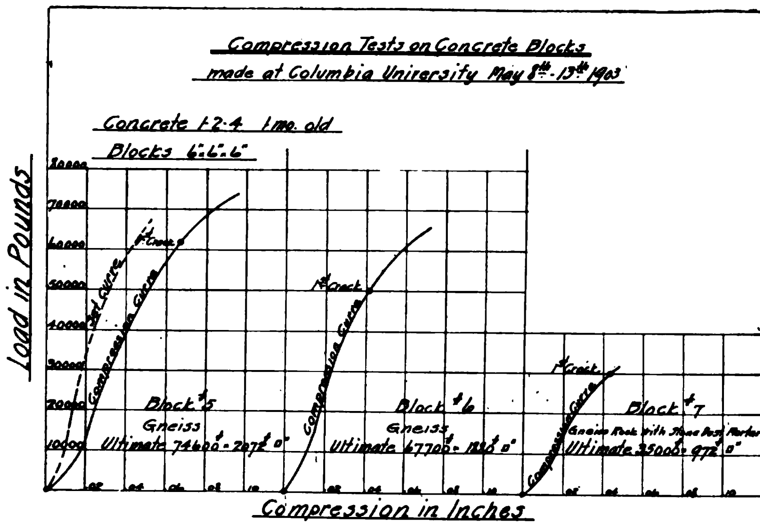


FIG. 1.

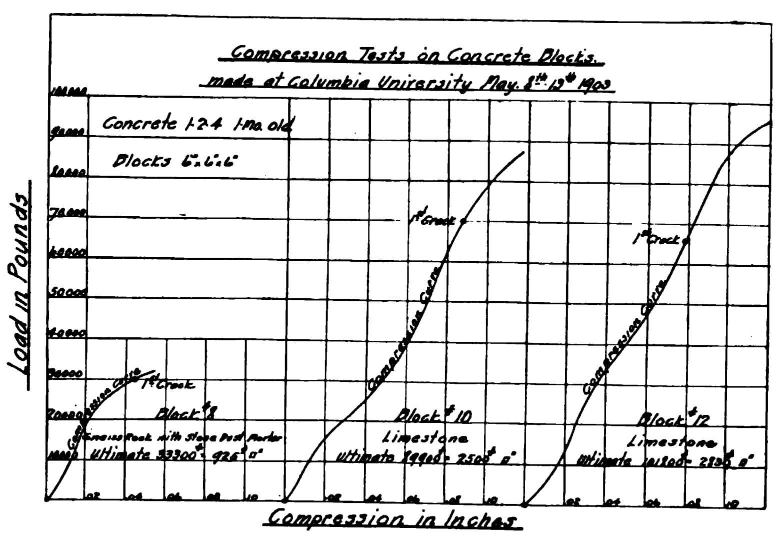


FIG. 2.

PLATE 8.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DIXON ON CONSTRUCTION DETAILS
OF REINFORCED CONCRETE WORK.
DISCUSSION BY S. DAHM.

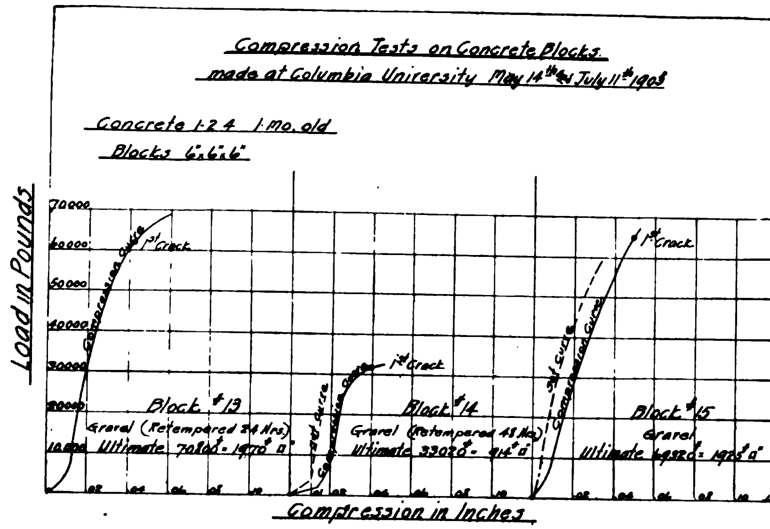


Fig. 1.

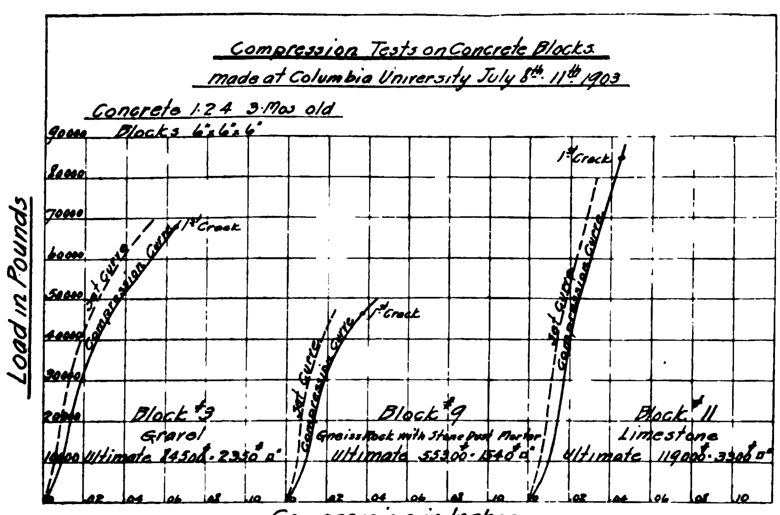


Fig. 2.

SUMMARY OF TESTS ON REINFORCED CONCRETE BEAMS (made at Columbia University May and July 1903)

Beam 8" x 8", 5'-0" lg. Span 4'-10" c to c of bearings
Eff. Area of Beam = 54□"
Gravel Concrete 1:2:4
Eff. Depth of Beam $6\frac{3}{4}$" Load applied at Center of Beam

TEST No.	AGE	KIND OF REINFORCEMENT	AREA OF STEEL Sq. Inches	1st CRACK LOAD	1st CRACK CENTER DEFLEC.	1st CRACK PERM. SET	1st CRACK STRESS PER □" CONCRETE	1st CRACK STRESS PER □" STEEL	ULTIMATE LOAD
1	1 Mo.	3-½" Dia. Thacher Soft	.574	8500#	.086"	—	1700	37800	10380#
2	"	" " " Medium	"	6100#	.067"	—	1220	27100	11340#
3	"	3-⅜" Sq. Rods Plain	.422	7950#	.089"	—	1750	47800	10800#
4	"	3-½" Dia. Thacher High	.574	8200#	.095"	.021"	1640	36400	11350#
5	"	3-⅜" Twisted Rods	.422	7500#	.092"	.020"	1650	44500	11230#
6	"	6-¼" Dia. Hennebique (water)	.295	6000#	.088"	.017"	1460	49000	9100#
7	"	" " " Air	"	6000#	.069"	"	"	"	10330#
8	"	3-½" Corrugated Rods	.590	10500#	.105"	.020"	2100	45800	14920#
9	"	3-⅜" Twisted Rods (with Stirrups)	.422	6800#	.078"	.017"	1500	40000	12440#
10	3 Mos.	3-⅜" Sq. Rods Plain	"	5500#	.054"	.016"	1210	32600	11050#
11	"	3-½" Dia. Thacher High	.574	6400#	.065"	.019"	1280	28400	12430#
12	"	" " " Medium	"	7000#	.065"	.018"	1400	31000	12740#
13	"	3-⅜" Twisted Rods	.422	7500#	.083"	.027"	1650	44300	15650#
14	"	6-¼" Dia. Hennebique (Air)	.295	5500#	.054"	.020"	1340	45000	11120#
15	"	3-½" Corrugated Rods	.590	7000#	.072"	"	1400	30500	15780#
16	"	3-⅜" Twisted Rods (with Stirrups)	.422	7100#	.070"	.018"	1560	42000	16570#
17	"	3-½" Dia. Thacher Soft	.574	5500#	.054"	.016"	1100	24500	10690#
18	"	6-¼" Dia. Hennebique (Water)	.295	7000#	.066"	.019"	1700	57000	11920#

QUALITIES OF STEEL RODS

KIND	ULTIMATE PER □"	EL. LIMIT PER □"
½" Dia. Thacher Soft	58000#	34000#
" " " Medium	66500#	40000#
" " " High	70000#	45000#
⅜" Sq. Rods Plain	62000#	42600#
" " " Twisted	80700#	55000#
¼" Dia. Hennebique	66100#	45000#
½" Corrugated Rods	93700#	62000#

Formulae for Calculating Stresses fs = Steel and fc = Concrete

$Es = 30\,000\,000 \quad y^2 = \frac{2ae}{b}\,\frac{Es}{Ec}$

$Ec = 1\,500\,000$

$M = fc\,\frac{by^2}{3y} + fs\,ae$

$fc = fs\,\frac{Ec}{Es}\,\frac{y}{e}$

b, y, e, a, neutral axis

These formulae can only be used up to the Elastic limit as beyond this the ratio between the moduli of Elasticity is changed

FIG. 1.

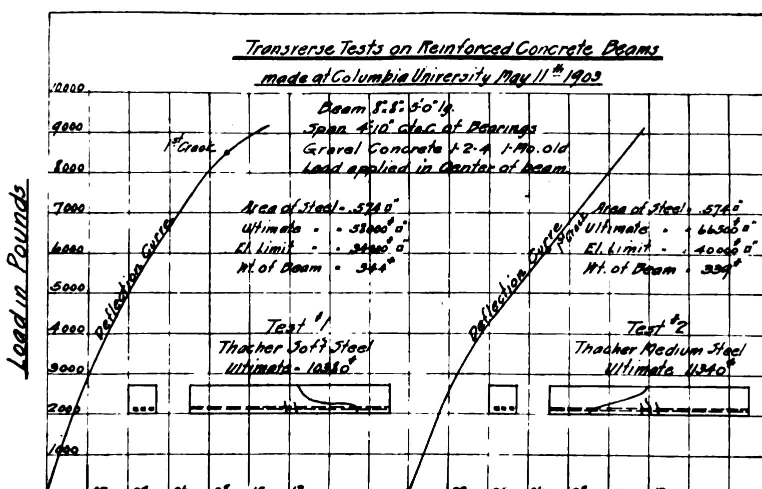


FIG. 2.

PLATE 10.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DIXON ON CONSTRUCTION DETAILS
OF REINFORCED CONCRETE WORK.
DISCUSSION BY S. DAHM.

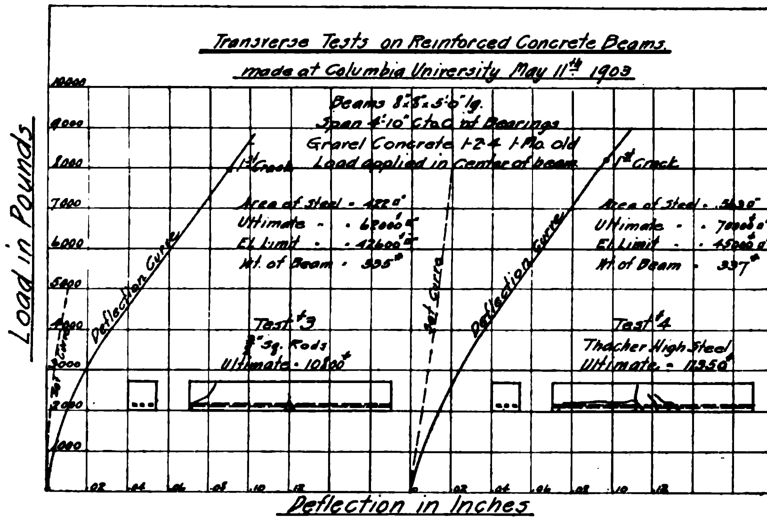


FIG. 1.

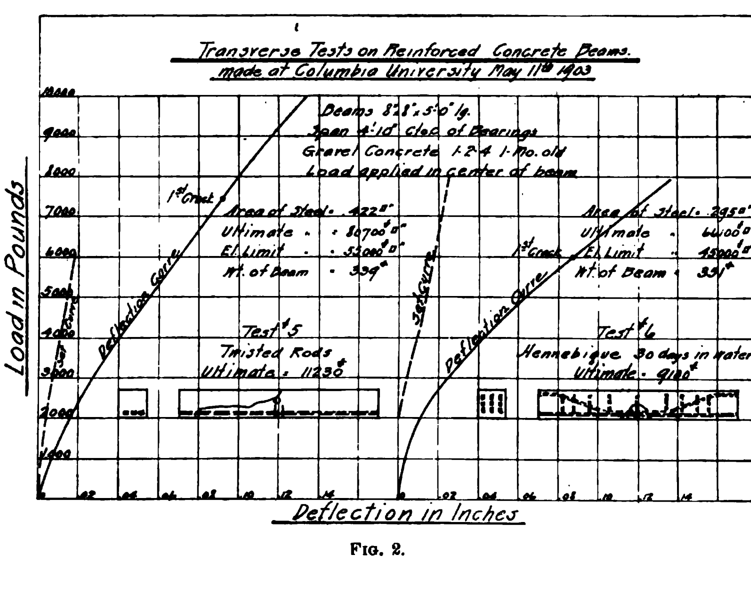


FIG. 2.

PLATE 11.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DIXON ON CONSTRUCTION DETAILS
OF REINFORCED CONCRETE WORK.
DISCUSSION BY S. DAHM.

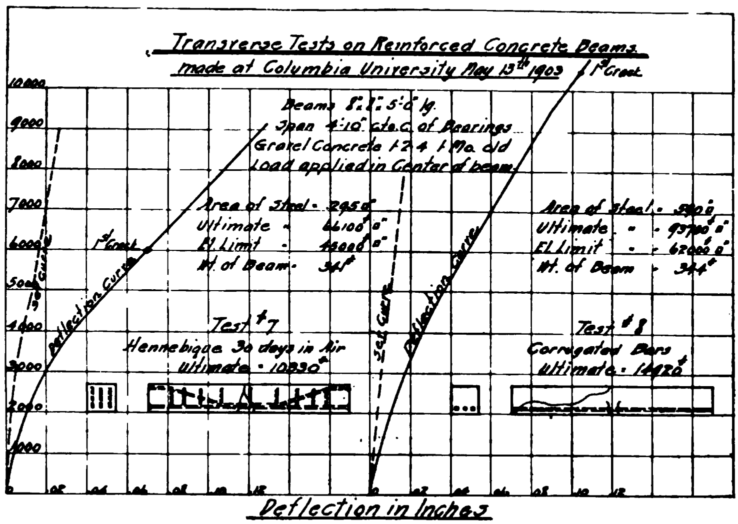


Fig. 1.

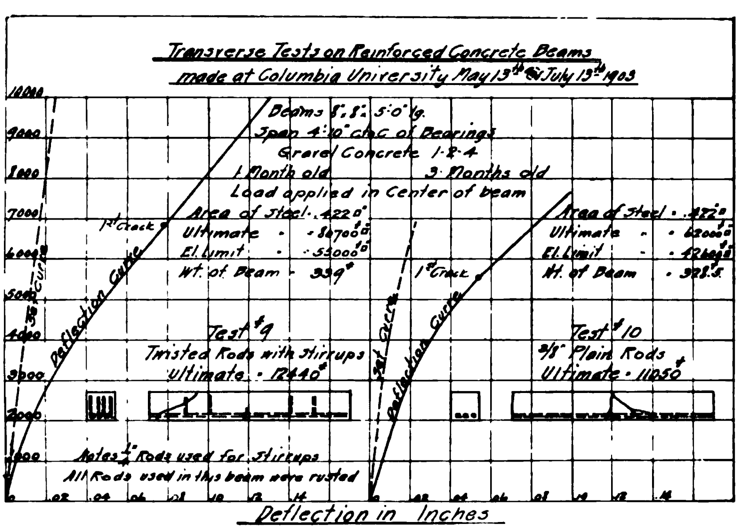


Fig. 2.

PLATE 12.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DIXON ON CONSTRUCTION DETAILS
OF REINFORCED CONCRETE WORK.
DISCUSSION BY S. DAHM.

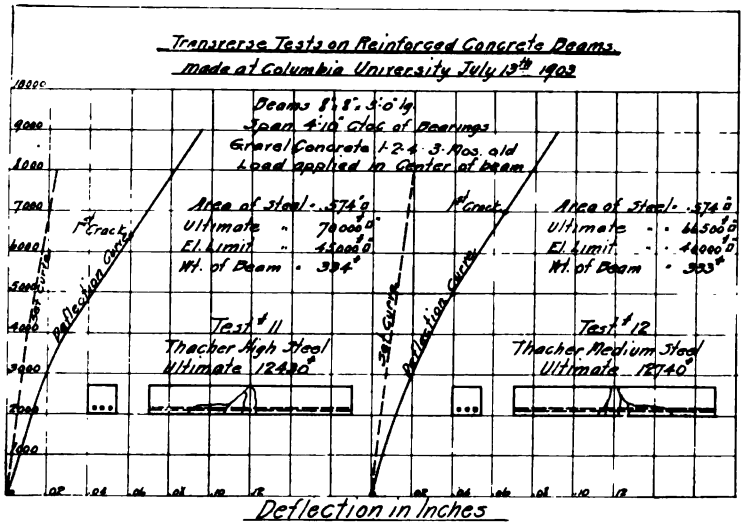


FIG. 1.

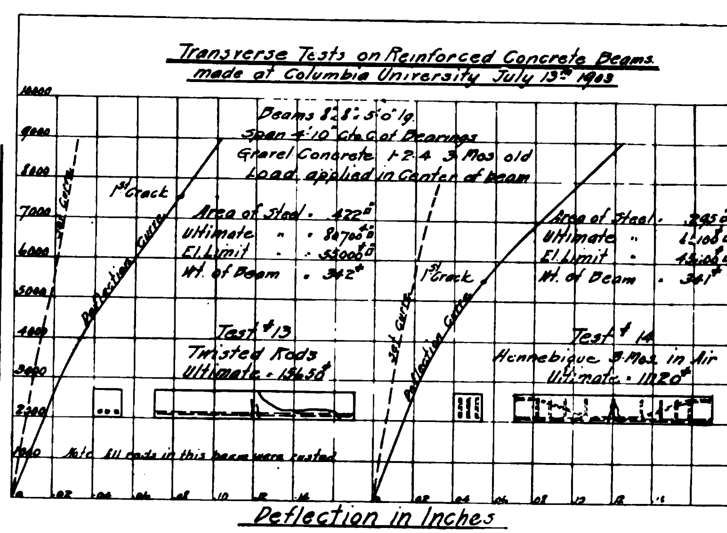


FIG. 2.

PLATE 13.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DIXON ON CONSTRUCTION DETAILS
OF REINFORCED CONCRETE WORK.
DISCUSSION BY S. DAHM.

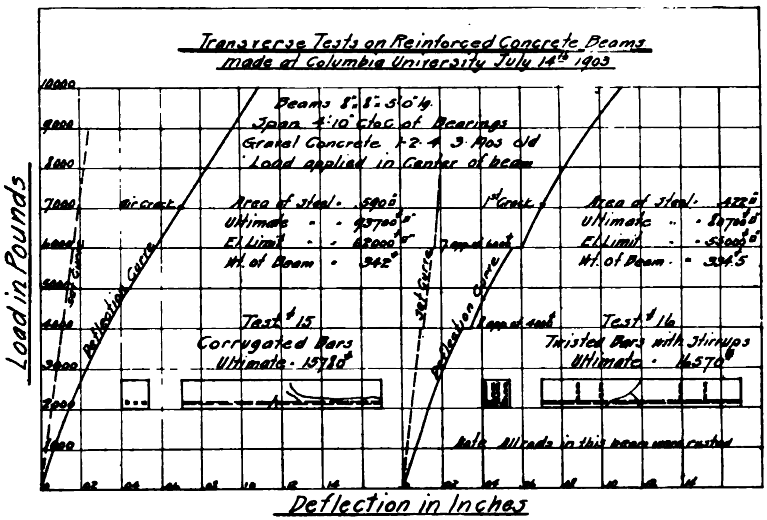


FIG. 1.

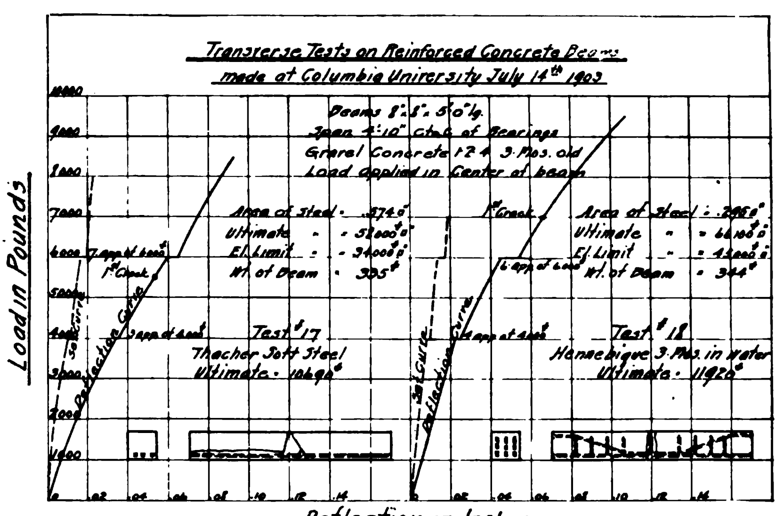


FIG. 2.

The concrete blocks were 6-in. cubes composed of one part Portland cement, two parts sand, and four parts gravel or stone-gneiss or limestone. The limestone concrete was the strongest. The ultimate stress for gravel concrete one month old was more than 1 800 lb. per sq. in. In only one case was the ultimate stress a little below this figure.

Some of the blocks were one month old and some three months old, the latter being about 30% stronger than the former. The compression of the blocks was measured for each additional 10 000 lb. load and in testing some of the blocks the load was removed after each new application to determin how much of the compression was permanent and how much was elastic. As is well known, concrete is a very imperfectly elastic material and it was found that a repeated application of the same load would increase the permanent deflection even for a comparativly small load. The modulus of elasticity is not constant, but increases by the higher stress.

It would be an interesting experiment to test a concrete block by the application of a load well within the elastic limit and apply it repeatedly for a long time. Our limited observations in this respect indicated a gradual decrease in the additions to the permanent set.

Tests were undertaken of steel rods partially buried in concrete to determin the adhesion and friction between steel and concrete. The rods were $\frac{3}{4}$-in. and $\frac{7}{8}$-in. square rods buried 9 in. in concrete and the force necessary to pull these rods out of the concrete was measured.

The adhesion and friction between the steel rods and concrete, when the rods were not painted or oiled, averaged from 430 lb. to 650 lb. per sq. in., superficial area. If the rods were painted or oiled, they lost entirely their grip on the concrete.

The beams which were tested had a span of 4 ft. 10 in. C. to C. of bearings, and had one load in the center of the span. The cross-section of the beams was 8 in. by 8 in. of concrete with steel rods near the bottom of the section. The area of the steel varied in the different sections from about 0.3 sq. in. to 0.6 sq. in. The effectiv depth of the beams was about $6\frac{3}{4}$ in. The beams were made up one month and three months before being tested. The center load required to break these beams came very near the theoretical load arrived at by assuming that the tension in the beam is all taken by the steel rods and that the compressiv stress in the concrete as well as the strain for each fiber is proportional to its distance from the neutral fiber.

The following plates will show the details of the tests and the results thereof (see Plates 5-13, inclusiv):

MR. GEORGE L. CHRISTIAN.—The specifications for reinforced concrete invariably require that the steel shall be free from rust. It seems to be the universal custom of all those who furnish steel to send it to the work in open cars. It therefore comes on the work covered with a thin film of rust. The question is, how far is the Engineer to be required to go in the enforcement of those specifications. Some Engineers claim that the presence of rust need not be considered in practice and permit the use of steel so incrusted; other Engineers, equally competent, refuse to accept steel in that shape and require it to be cleaned. I would like to ask what is the practise of the Turner Construction Company?

MR. DIXON.—I would say that it is very important that the steel shall not have rust which has formed a scale on it. If there is a scale, that must be removed with wire brushes or by some other method. If the rust is merely a film, which you can rub off, we never felt that it was objectionable.

MR. GEORGE S. RICE.—I will corroborate Mr. Dixon's statement. When we first commenced our Rapid Transit work, all metal was to be covered with paint of some kind, but after 1902, when we had considerable reinforced concrete construction, we realized, particularly after the experiments of which Mr. Dahm spoke, that we did not need to have the rods painted, or the steel painted, and then we countermanded our orders and requested that the steel be not painted, because we found it was better, but at the same time we never allowed it to get into a condition of a scale; it was only covered with a little film of rust, which made practically no difference.

A MEMBER.—In the slides which Mr. Dixon gave and in his description of the various constituents of reinforced concrete, he spoke of the specifications, but he did not treat, nor did any of the illustrations show the method of mixing concrete. What I desire to know is whether he had it machine mixt or hand mixt and in what proportion the mix should be to bring about the best result. He no dout has had experience in that respect.

MR. DIXON.—I would say regarding the question of mixing, that it, of course, depends largely on the size of the job. On nearly all jobs in the city we have mixers handy and we use the mixer there anyway. Of course, in small work, such as that on subway stations, that was all done by hand. If hand work is well done it certainly serves every purpose, tho the concrete obtained by hand mixing is not quite as strong as that obtained by machine mixing. I believe the tests showed that. But hand-mixt concrete, if mixt right, is an excellent product. Take the Vanderbilt stairway I showed you; that concrete was hand mixt and I do not know of any concrete ever having been put to a severer test than that. But on

a large job, however, the question of cost and practicability enters largely into consideration.

A Member.—Have any actual tests been made as to the effect of rust upon the bonding of the steel to the concrete, or is it merely a matter of opinion?

Mr. Sverre Dahm.—The tests made at Columbia University showed the rusted bars to have the better grip upon the concrete.

A Member.—Were the bars completely covered with rust, or only partially so?

Mr. Dahm.—Only partially covered.

A Member.—I would like to ask Mr. Dixon what is the approximate rate of progress he considers advisable in concrete.

Mr. Dixon.—The question of the rate of progress, of course, depends entirely on the weather and on the money you can afford to spend for forms. On large bildings during the summer time in some instances the rate of progress was a floor in eight working days, as, for instance, on those Bush Bildings, and the rate of progress on the Eastman and Rogers and Pyatt Bildings was a floor a week, but at this cold time of the year we do not make quite such rapid progress. In fact, a floor in three weeks on an average is about as much as we do.

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.

Paper No. 31.

PRESENTED MARCH 27, 1907.

THE GEOLOGY OF LONG ILAND AND ITS PRACTICAL RELATION TO UNDERGROUND WATER SUPPLIES.

BY MR. ALEXANDER S. FARMER,* MEMBER OF THE SOCIETY.

WITH DISCUSSION BY

GEORGE S. RICE AND WM. W. BRUSH.

THE BIRTH OF LONG ILAND.

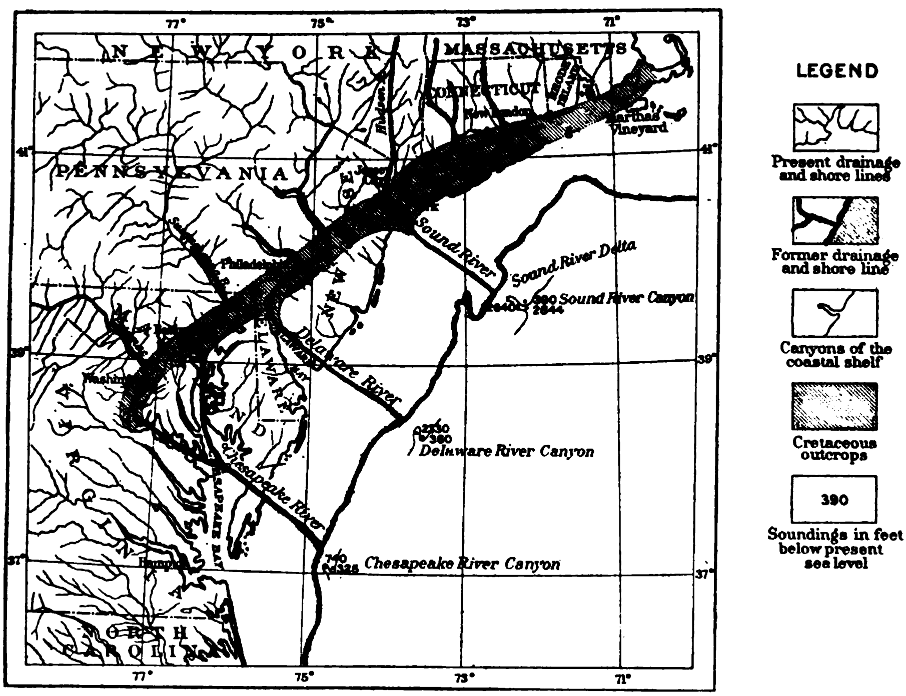
Long Iland is the largest iland along the Atlantic seaboard. It is about 115 miles in length and about 12 miles wide. Its area is 1 682 square miles or considerably over 1 000 000 acres. It is composed of sands, clays and gravels, lying on top of the bed rock. The only outcroppings of this rock show at Long Iland City, being the continuation of the Fordham Gray Gneiss, and which rapidly dip below the surface.

In the late Pliocene period of the Tertiary Era, the shore line along this part of the Atlantic border was about 100 miles seaward from its present position. (See Plate 14.)

These facts have been determined by soundings made by the U. S. Coast and Geodetic Survey, the submerged river channels being located with a considerable degree of accuracy.

On the New England border of the continent and for 1 000 miles west, the mountains and elevations were then much higher. The Hudson River and the Connecticut River joined together to form the great Sound River which flowed across what is now the western part

*Assistant Engineer, Aqueduct Commissioners.

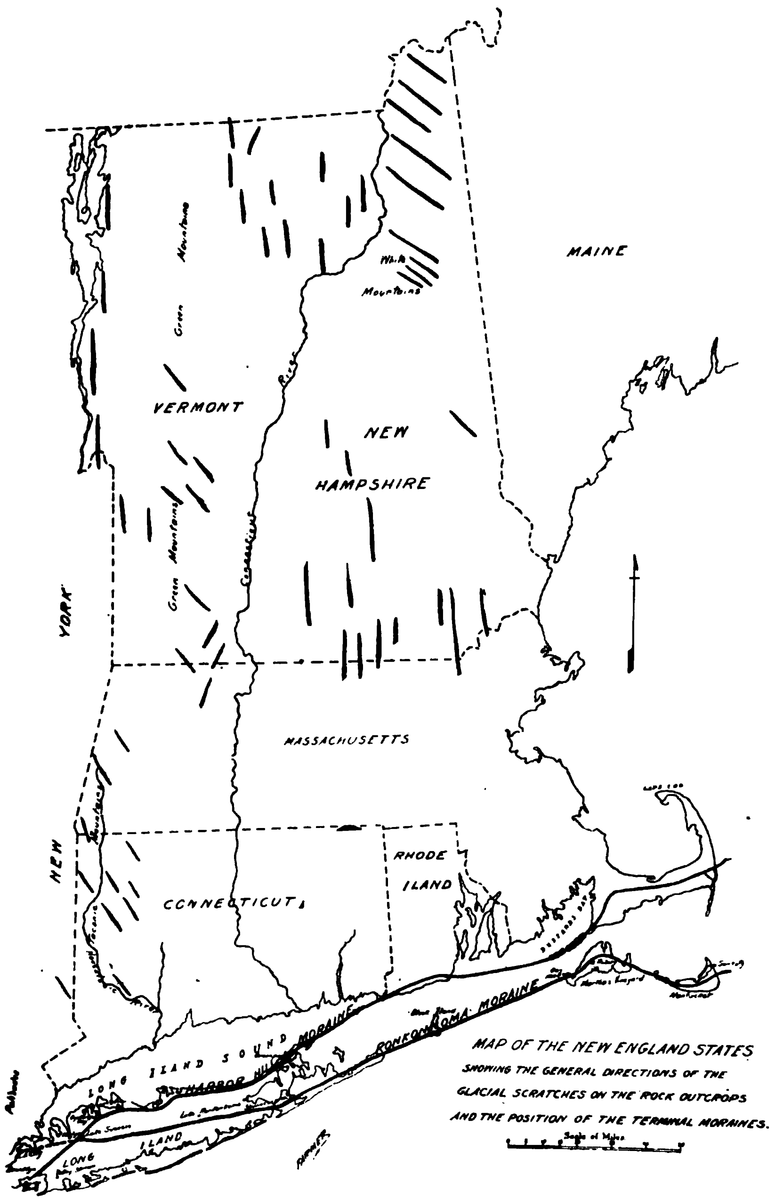


POST-LAFAYETTE EROSION INTERVAL

Scale
100 50 25 0 100 200 300 miles

PUBLISHED BY PERMISSION OF A. C. VEATCH, ASSISTANT GEOLOGIST, U. S. GEOLOGICAL SURVEY.

PLATE 15.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FARMER ON LONG ILAND
UNDERGROUND WATER SUPPLIES.



MAP OF THE NEW ENGLAND STATES
SHOWING THE GENERAL DIRECTIONS OF THE
GLACIAL SCRATCHES ON THE ROCK OUTCROPS
AND THE POSITION OF THE TERMINAL MORAINES.

of Long Iland in the vicinity of Jamaica Bay. There was no Long Iland in those times. What afterward became the nucleus of Long Iland was composed of Cretaceous outcrops of clays and sands, which extended in a belt from Cape Cod southwest to the Potomac River.

The Palisade range along the Hudson, then as now resting on top of the Triassic red sand-stone, overlookt a deep canyon which has now been silted up and submerged due to the subsidence in the land since that remote period.

Following the initial position of the ancient shore line of the Atlantic border, as shown on Plate 14, came a period of subsidence, and the Cretaceous outcrops (beds of clay and sand similar to those in the vicinity of Perth Amboy, N. J.) became a chain of ilands and the first Long Iland was formed as one of them. The land on the New England border had then attained high elevations and the Polar ice cap came creeping southward. The first continental glacier advanced toward this primeval Long Iland and great beds of gravel were deposited over eastern and western Long Iland and also upon the ilands which now appear in Long Iland Sound.

The ice of the first glacier then retreated, the subsidence continued and beds of sand and clay, peat and lignite were formed in quiet waters. After this interglacial period the ice returned three successiv times, viz., in the "Gay Head Folding interval,"* in the "Tisbury interval,"* which brought great outwash deposits of yellow sand and gravel, and in the last interval, the "Wisconsin Drift,"* which spread its terminal moraines on top of the Tisbury deposits, and which shows in the two lines of morainic hills which traverse the north and south shores of Long Iland.

These moraines of the Wisconsin ice are simply a mantle over the older deposits; underneath, and observable, in many places on the iland, the yellow Tisbury and the older Cretaceous clay can be seen.

On the Path of the Glacier.

From whence did all this shifted soil come? It is evident that Long Iland has been a spoil-bank for successiv generations of glacial outwash deposits and glacial moraines, and before these the

*From the nomenclature of Mr. A. C. Veatch, Assistant Geologist, U. S. Geological Survey.

underlying clays and sands were formed by erosion and corrosion of the rocks on the mainland. All soil is disintegrated rock and the rocky protaxis of the White, Green and Taconic Mountains form some of the oldest land on the continent of North America. There was sufficient time before the first glacier appeared for the rocks of this early region in geological history to suffer the ravages of the elements, and to resolve themselves into their component parts, and, being transported by river and flood, to form beds of clay and sand at the end of the journey. The glaciers then took up the work. The hight of the ice in the region of the White Mountains was perhaps 6 500 ft. Mt. Washington, 6 300 ft. in elevation, was covered, and Mt. Mansfield in Vermont, about 4 400 ft. high, was wholly under the ice sheet.

The ice in the Adirondack region in New York State flowed south-southeastward into the vicinity of the White Mountains and entirely over the Green Mountains in Vermont, and was perhaps 4 000 to 5 000 ft. in thickness. This immense sea of ice, a mile high, carried everything before it. Great cliffs were broken off and ground to flour. The path of the glacier can be traced by the deep grooves or striations, apparent to this day, on the rock outcrops. (See Plate 15.)

The general direction of the glacier in the New England States was south-southeast, and the evidence is conclusiv that its ultimate end, the terminal moraine, would assume some such position as it now does on the southern shores of New England, on the ilands in the Sound, and on Long Iland.

From the appearance of the morainic mass an idea can be had of the distance traveled by the broken rock. In a journey of a few miles, the rock, upon the recession of the ice sheet, would be left as boulders. In a journey of three hundred miles it would be reduced to fine particles.

A study of the early New England mountains shows the profound ravages of erosion by glacial action. High up on the summits of the principal peaks in the White Mountains evidences of glacial markings can be discerned on the struck or stoss side. In general, these mountains show the Conway granite at the base and felsites at the summit. From the felsites are formed the clay beds of various colors, due to the presence of hornblende and mica, which

FIG. 1.—SCENE IN WHITE MOUNTAINS ABOVE TIMBER LINE, SHOWING MT. PLEASANT IN FOREGROUND; MT. WASHINGTON, MT. MONROE AND MT. ADAMS.

FIG. 2.—BOULDERS ON THE BEACH, GREENPORT, L. I.

FIG. 3.—ARTESIAN WELL, OYSTER BAY, L. I.

FIG. 1.—BLUFF AT SIASCONSET, SANKATY HEAD, ILAND OF NANTUCKET.

FIG. 2.—COLORED CLAY CLIFFS AT GAY HEAD, MARTHA'S VINEYARD.

contain appreciable quantities of iron. Above the timber line the flora is essentially Arctic and has been correlated with the now existing flora of Greenland. (See Plate 16, Fig. 1.)

THE RONKONKOMA AND HARBOR HILL MORAINES.*

These are the terminal moraines of the Wisconsin ice—called Wisconsin from the fact that the first official study of the movement of the continental glacier was made in the Wisconsin district.

The Ronkonkoma Moraine (see Plate 15) passes thru Nantucket, Martha's Vineyard, Block Iland, the Shinnecock Hills on the south shore of Long Iland, and then thru the center of Long Iland to Long Iland City.

The iland of Nantucket, located about 75 miles from Long Iland, marks the extreme southeastern limit of glacial action in North America. Its length is about 14 miles and average width 2 miles. The north shore has very irregular topography, morainic hills and kettle holes, and but few boulders. The south shore seems level, with gravel on the surface, this being the outwash from the north shore deposits. The soil produces a stunted growth of conifers similar to those on the eastern end of Long Iland.

The bluff at Siasconset, Sankaty Head, about 80 ft. high (see Plate 17, Fig. 1), shows stratified sands and gravels. We know that there are Cretaceous clays at the bottom, but the talus and vegetation conceal them.

Sankaty Head is a district of blue clays and has given the name "Sankaty" to that particular formation of the interglacial period.

Passing thru Martha's Vineyard, the largest of the ilands off the south shore of New England, at West Tisbury, the Tisbury formation of yellow sand and gravel shows in exposed sections, but toward the southwestern end of the iland at Squibnocket the mantle of Wisconsin drift becomes apparent. The topography becomes complicated and many boulders show on the surface, having traveled across the channel from the Massachusetts shore. At the extreme southwestern end of the iland, Gay Head, the colored clays of the interglacial period are fully exposed. (See Plate 17, Fig. 2.)

These represent the Gay Head Folding epoch of Mr. A. C. Veatch. The clay beds are contorted into anticlines and synclines

*From the nomenclature of Mr. A. C. Veatch, Assistant Geologist, U. S. Geological Survey.

due to ice pressure and the tops have been truncated, due to erosion from wave action. The clays are white, red, black and buff in color. The black clay has been thus colored by lignite and the fine white siliceous clay has been bleached by the presence of the carbon dioxid in the lignite bed beneath it, showing a fine example of a coal bed in embryo, similar conditions existing in all coal measures.

The red clays are formed of decomposed feldspar, colored by hornblende and mica. The buff-colored clays are generally white underneath, the yellow color being due to outwash over the cliff.

The next manifestation of the Ronkonkoma Moraine is seen in Block Iland. At Clay Head, red and white clays are exposed.

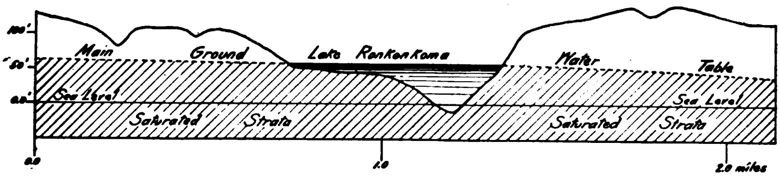
The evidence seems conclusiv that these three ilands, and also Long Iland, as we shall presently see, had a common origin—the basal Cretaceous clays being covered by the later Tisbury and Wisconsin drift.

On Long Iland, in the region of the Shinnecock Hills, between Montauk Point and Canoe Place, the morainic hills are of low elevation. The deposit of drift is of comparativly small depth and the yellow Tisbury sand and gravel is exposed on the road cuts of the new highway into Southampton.

Kettle holes in the moraine, containing lakes of economic importance, become abundant as the moraine advances westward thru Long Iland. The largest of these is Lake Ronkonkoma (see Plate 18, Fig. 1). It is located near the center of the iland. Its level rises and falls in direct connection with the fluctuations of the main ground water table.

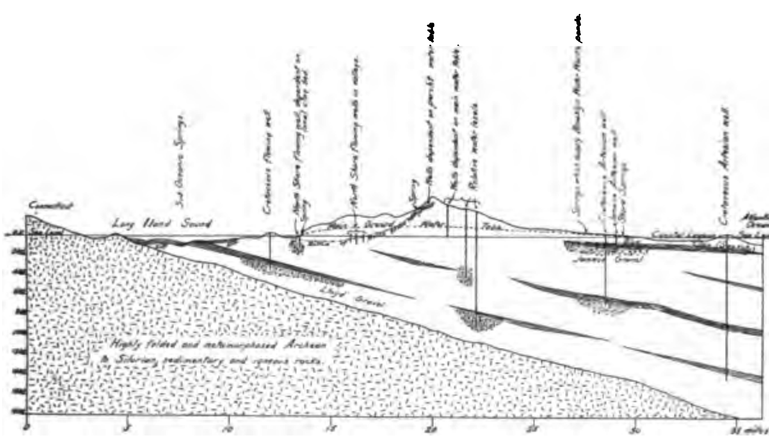
There is very apparent evidence along the shores of Lake Ronkonkoma that its flow line has been higher at some former period. A beach and terrace formation can be seen. The hight of the first terrace is now about 6 ft. above the beach.

The hills along the north shore of Long Iland form the Harbor Hill Moraine, so called from Harbor Hill at Roslyn, at the end of Hempstead Harbor. Harbor Hill is 384 ft. high, being the highest elevation on Long Iland. This moraine has its easterly extension on the Cap Cod peninsula, passes westerly across the south end of Buzzards Bay, thru the southern part of Rhode Iland, along the north shore of Long Iland, crosses Long Iland at its western extremity to reappear again in Staten Iland. Along the north shore



Lake Ronkonkoma: an example of a Kettle-hole lake depending on the main ground water table.
After A. C. Veatch

FIG. 1.



Diagrammatic Cross Section of Long Island, Showing General Water Conditions and Cause of Flowing Wells.
After A. C. Veatch

FIG. 2.

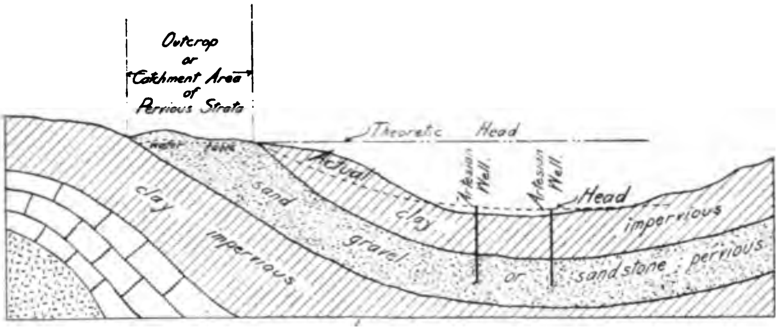
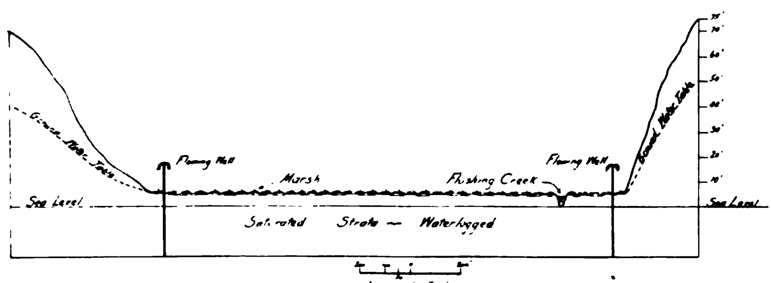


Diagram showing common position of strata producing Artesian or Flowing Wells.

FIG. 1.



Section at Flushing Creek — Station Nos 3, 4, and 5
Citizens Water Supply Co
Boro of Queens, Long Island

An example of a North Shore excavated valley showing the phenomena of flowing wells.

FIG. 2.

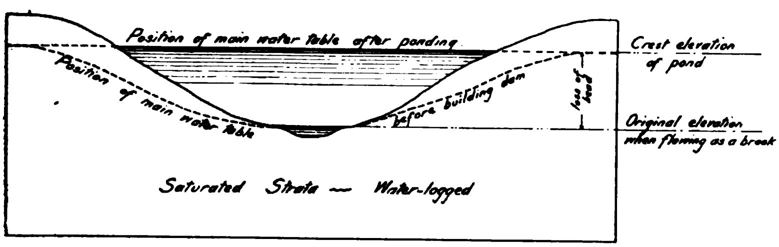


Diagram showing that the ponding of any excavated valley which cuts the main water table, reduces the spring flow. The discharge from the crest elevation of the pond will be less than that of the original brook.

FIG. 1.

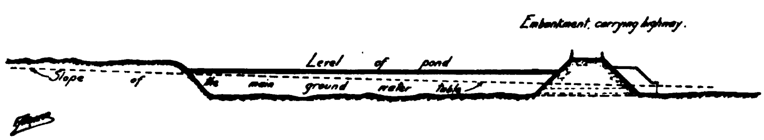


Diagram showing the method of ponding along the South Shore of Long Iland

FIG. 2.

toward the eastern extremity of Long Iland large strays or erratics are found. Plate 16, Fig. 2, shows several on the beach at Greenport. They are composed of granit, evidently from some outcrop in Massachusetts, carried along on the ice across the intervening space and left behind when the ice melted. The elevations of the moraine at this end of the iland are generally low. Low hills are typical in the district about Wading River, but passing westward the hills increase in hight and the 200-ft. contour becomes common.

The Wisconsin drift covers Long Iland at variable depths, ranging from 10 ft. to 200 ft. It is the material of the terminal moraines. It is composed of sand, boulder clay and small multicolored stones, with large strays or erratics weighing from 5 tons to 300 tons, which have been carried to Long Iland on the ice stream and there abandoned. Sections exposed by excavation for highways or for commercial purposes to secure sand and gravel show the mantle of Wisconsin drift covering the earlier Tisbury (see Plate 24, Fig. 2).

The value of the Wisconsin drift as a water horizon is small on account of its heterogeneous character.

General Geologic Conditions on Long Iland.

From the Connecticut shore of Long Iland Sound the rock dips rapidly, approximately 60 ft. to the mile. Overlying the rock are beds of clay and gravel, brought down by the earlier glaciers, and on top of these lie the terminal moraines of the Wisconsin drift. (See Plate 18, Fig. 2.)

It has been estimated that the rate of subsidence on this part of the Atlantic border is about 2 ft. per century. In the eastern end of Long Iland Sound are numerous shoals and ilands. If this district were elevated 150 ft. it would form part of the mainland, and at the above rate of subsidence it would indicate that condition as having existed approximately 7 500 years ago. At that time Long Iland Sound was cut off from the sea and received the waters of the mighty rivers of Tertiary times which gradually wore back the escarpment along the present north shore. The glacier later plowed across and cut this trough deeper, depositing its débris over the older deposits. This condition, with continued subsidence, opened Long Iland Sound at its eastern end to the sea. The deep bays on

the north shore coincide with the direction of the glacial movement —south-southeast. They were evidently formed by the thrust of large masses of the ice sheet, and being prolonged into the land, created the deep valleys which were still further widened as the ice melted by the erosiv action of the escaping water.

These excavated valleys can be seen at Huntington, Cold Spring, Oyster Bay, Roslyn, Manhasset, Little Neck Bay, Flushing and other places.

The main ground water table has been cut by these valleys and consequently a spring flow results which forms a creek flowing toward the Sound.

The yellow Tisbury gravel lies under the morainic drift, and also lies exposed over most of the plain south of the moraine. Under the yellow gravel is the blue clay formation (Sankaty) similar to that on Nantucket. Beneath the Sankaty clays are the Jameco gravels, and passing downward the Upper Cretaceous clays and gravel are found on top of the bed rock.

In its relation to underground waters, the position of Long Iland is insular, in that it is not connected with the mainland. The only way that it can receive any of the subterranean waters of the mainland is thru faults in the underlying rock, a somewhat improbable condition.

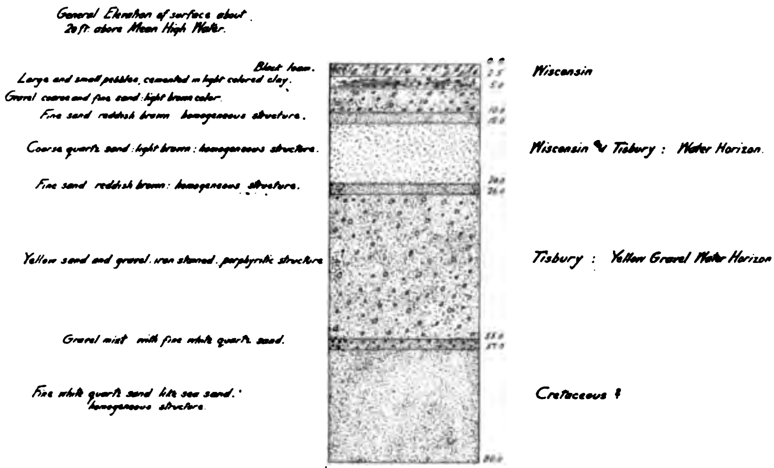
It is therefore essentially dependent upon the rainfall for its supply. The great porosity of the sands and gravels prevent evaporation and hence the scarcity of surface streams on the iland. These sands and gravels, however, form an immense underground reservoir, become saturated, and water escapes both along the north and south shores. There are no underground rivers on Long Iland, such a condition being possible only in limestone formations.

ARTESIAN WELLS.

Artesian or flowing wells are common along the north shore of Long Iland in the deep eroded valleys. In these re-entrant valleys the slope of the main ground water table gives a great head of water and hence the velocity of flow is considerable.

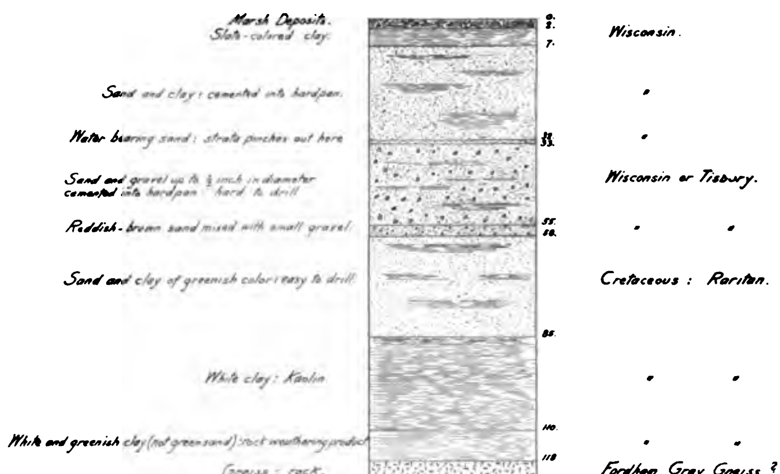
Artesian wells (see Plate 19, Fig. 1) are usually found where a pervious stratum lies between impervious formations; this stratum must then outcrop on the surface and pass between the impervious strata as a syncline or trough.

PLATE 21.
THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.
FARMER ON LONG ILAND UNDERGROUND WATER SUPPLIES.



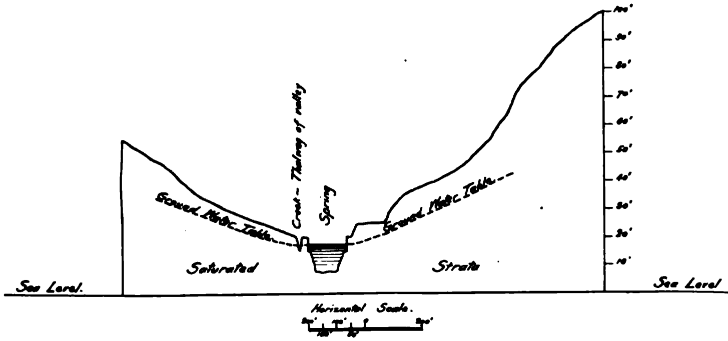
Typical section and record of a test well at Flushing Pumping Station.
Boro of Queens, L. I.
Department of Water Supply, Gas and Electricity.
New York City.

FIG. 1.



Section and record of a test boring at Station No. 3,
L.I.R.R. and Grove St., L.I. City, Boro of Queens.
Department of Water Supply, Gas & Electricity.
New York City

FIG. 2.



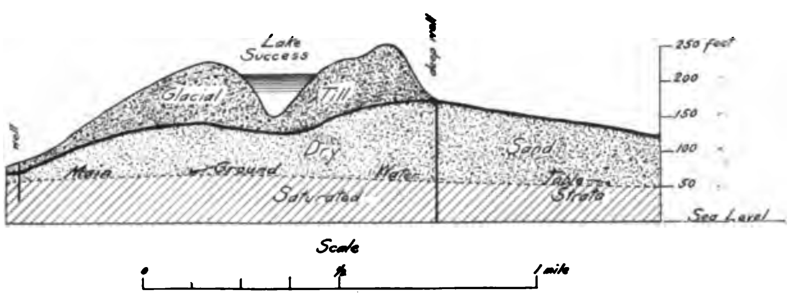
Section at Flushing Pumping Station — Kassena Spring.
Boro of Queens, Long Iland

An example of a natural spring fed by the ground water table.

Department of Water Supply, Gas and Electricity.

New York City.

FIG. 1.



Lake Success : an example of a kettle-hole lake depending on local impervious strata.
After A.C. Veatch.

FIG. 2.

The common idea in regard to artesian wells is that they must be produced from a water bearing sandstone or limestone confined between impervious strata of granit. This is true enough, but on Long Iland the conditions are precisely the same, only that the pervious stratum is porous sand and gravel and the impervious stratum is clay.

The artesian wells of magnitude on Long Iland have their parentage in the coarse Jameco gravels which underlie the Sankaty clay and also in the Cretaceous gravels which pass under the clay sheet, but at a greater depth.

An example of an artesian well is the one at the New York State Fishery Commission, at Cold Spring, which is 6 in. in diameter, 80 ft. deep, and is probably situated in Jameco gravel (see Plate 24, Fig. 1). The discharge is about 300 000 gal. per 24 hr., with a velocity of about 2.3 ft. per sec. It is located in the eroded valley of Cold Spring Harbor, just below the first pond toward the harbor.

At Oyster Bay, artesian wells have been developt extensively. This district is also in an eroded valley, and as in the former case, the main ground water table is at considerable hight above the surface of the valley. The head developt by the hight of the main ground water table is so considerable that flowing wells are found within a few feet of the salt water of Oyster Bay Harbor.

Plate 16, Fig. 3, shows an example of an artesian well at Oyster Bay. It is 3 in. in diameter and about 165 ft. deep, in sand and gravel. The discharge is about 100 000 gal. per 24 hr. The phenomena of flowing wells are found in every excavated valley along the north shore. In the valley of Flushing Creek, in which the highest contour is only 75 ft., this condition is made use of for furnishing a supply of water to the pumping stations of the Citizens Water Supply Company. (See Plate 19, Fig. 2.) The water rises here about 8 ft. above the surface and flows into a flume to a pumping well. The ground water table generally follows the topography of the surface, and saturated or water-logged strata are found at or near the surface of the valley. The hight of the water table above the foot of the cut or erosion gives a head of water on the well. In this particular case the discharge is increast by the use of comprest air, which will be explained further on.

The examples of the wells shown are merely indicativ of the

artesian character of the sub-surface in these vicinities, and also of the immense amount of water flowing seaward and reaching its objectiv in the form of sub-oceanic springs.

The Ponding of the North Shore Excavated Valleys.

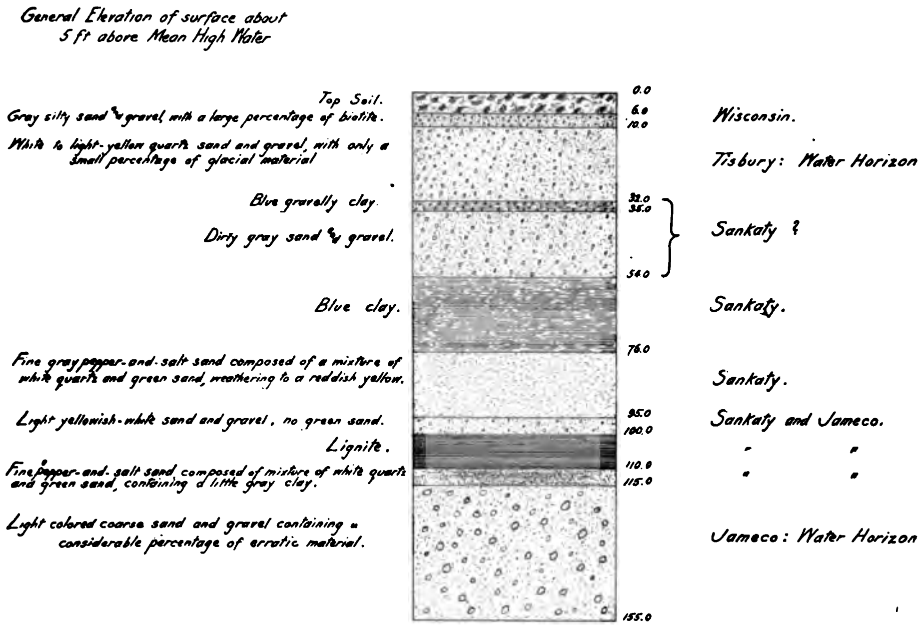
As before stated, the main ground water table is cut by the sides or slopes of the eroded valley. This condition results in a brook flow, running down the valley toward the Sound. It is obvious that the head of water on the brook will be considerable and the discharge a generous one. (See Plate 20, Fig. 1.) But in most of the cases of excavated valleys on the north shore the water is impounded by the simple expedient of bilding a dam across the valley, and the pond can be used either for water supply or for water power purposes.

When a dam is thrown across a valley and the water impounded in a reservoir, the position of the main ground water table promptly rises in direct relation with the level of the water in the pond. The overflow of the pond passes over a waste wier bilt in the dam. It is clear that the discharge over the spillway will be considerably less than the discharge from the original brook, on account of the loss of head due to the changed position of the water table.

An example of the ponding of a north shore excavated valley occurs at Cold Spring Harbor. A dam confines the waters of a chain of three ponds. The highest contour is about 200 ft. in the Tisbury formation. The pond behind this dam is about 15 ft. deep. The waste wier is 18 ft. wide and with a 2-in. head will discharge 3 600 000 gal. per 24 hr., wasted into Cold Spring Harbor (see Plate 25).

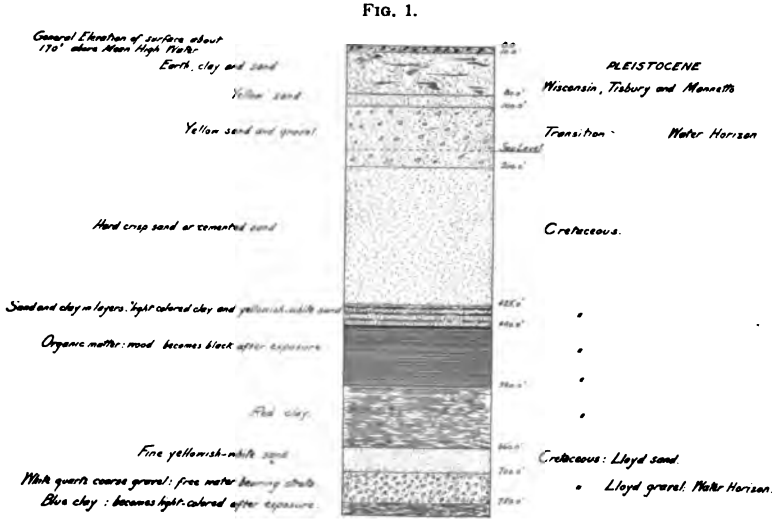
Ponding Along the South Shore.

The south shore of Long Iland was originally a great plain of yellow sand and gravel. It was so in the Tisbury time, but the outwash from the moraine has spread some of the Wisconsin over it and also eroded and reworked the Tisbury. The surface slopes from the foot of the moraine toward the sea. The water table follows the contour of the surface, and on the south shore near sea level it appears at the surface.



Typical section and record of a well at pumping station of the Queens County Water Co. Valley Stream. L. I.

FIG. 1.



Section and record of a deep well in the Lloyd Gravel at Lake Success. Nassau Co L. I.

FIG. 2.

This condition can be taken advantage of in any depression or eroded locality near sea level. (See Plate 20, Fig. 2.)

From Hempstead to Eastport, a distance of 50 miles, examples of ponding can be seen. The highway along the south shore crosses these deprest areas. Wherever this occurs, the embankment carrying the highway becomes a dam which impounds the water and forms a reservoir. The position of the water table becomes changed to the level of the pond and the overflow escapes over a waste wier.

The Water Horizons on Long Iland.

The strata on Long Iland do not lie in conformity. Their continuity is broken in many places. (See Plate 18, Fig. 2.) The strata have been distorted and in many cases have disappeared entirely. The distortion of the strata was probably due to the immense hight of ice on top of the land in glacial times, possibly 5 000 ft. in thickness. The pressure of the ice cap acting vertically downward on a more or less plastic foundation has squeezed out the clay. The breaks in the continuity of the strata can be accounted for by erosiv action of streams and floods. In other words, the substructure of Long Iland is not a homogeneous mass, and this accounts for the great difficulty in anticipating the geological section before the well boring has been made.

There are three principal water horizons on Long Iland, viz., the Tisbury, the Jameco Gravel and the Lloyd Gravel.

The Tisbury Water Horizon.

The Tisbury consists of the yellow sand and gravel deposits which probably extend over two-thirds of Long Iland. It is the top water horizon and most of the underground water is pumpt from it. It produces wells to a depth of about 50 to 60 ft., except when the overlying Wisconsin is deep. It is the home of the main ground water table. It is sometimes called the "Yellow Gravel Water Horizon."

A typical section and record is shown in Plate 21, Fig. 1, at the Flushing Pumping Station, Boro of Queens, of the Department of Water Supply, Gas and Electricity, New York City.

The overlying Wisconsin is about 12 ft. deep; then Wisconsin and Tisbury to 26 ft., and then all Tisbury to 55 ft. below the sur-

face. It is from the latter that the underground water is pumpt. The surface indication of the water-bearing strata at this locality has been known as Kassena Spring, and is an example of a natural spring fed by the main ground water table. (See Plate 22, Fig. 1.) It is a natural well. At this pumping station water is pumpt both from the spring and from wells. The same source of supply is indigenous to both. For over thirty years this spring has fed its surface water to the pumps.

The geological section was taken from a test boring made in the pond, and showed two well-defined water horizons separated by 2 ft. of fine sand. Underlying the lower Tisbury is a considerable depth of fine white quartz sand of impervious character, probably of Cretaceous origin.

It must, however, be borne in mind in this connection that while the surface indications may show the strata to be saturated or water-logged, the yield from the wells may not be in proportion to the expected supply. The reason for such results is probably due to the fact that the strainers at the bottom of the well pipe have not been placed in coarse water-bearing material of considerable depth, so that the well may have a large area to draw upon and at the same time the tendency to clog the strainer is considerably reduced.

The quality of the Tisbury water is good, having been naturally filtered thru the overlying beds of sand, except in those cases along the shore where excessiv pumping lowers the head of the ground water table and chlorine from the sea water creeps in.

Plate 21, Fig. 2, shows the extreme difficulty in locating the Tisbury where it might reasonably be expected to be found. This is a section and record of a test boring at Pumping Station No. 3, Long Iland City, belonging to the Department of Water Supply, Gas and Electricity, New York City.

Long Iland City is at the extreme end of the Ronkonkoma Moraine, and the Wisconsin Drift covers the whole of it. In its deposition, it has mixt its boulder clay and sand with the Tisbury, and if Tisbury occurs at all, it will occur only locally. The water-bearing sand in this locality lies in the form of a syncline or trough, and has a thickness of 10 ft., about 35 to 40 ft. below the surface, and yet less than 100 ft. away from the well line this water-bearing sand pincht out to 1 ft. in thickness! Underneath the

FIG. 1.—FLOWING WELL, N. Y. STATE FISHERY COMMISSION, COLD SPRING, L. I.

FIG. 2.—SAND AND GRAVEL PIT (TISBURY), HEMPSTEAD HARBOR, L. I.

PLATE 25.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FARMER ON LONG ILAND
UNDERGROUND WATER SUPPLIES.

WEIR AND SPILLWAY, FIRST POND, COLD SPRING, L. I.

mixt Wisconsin and Tisbury lie the Cretaceous clays directly over bed rock, which is here located 118 ft. below the surface.

The Jameco Gravel Water Horizon.

The Jameco gravel water horizon, so called from the pumping station of the Brooklyn Water-Works at Jameco, L. I., where the test borings were given systematic study, lies below the Tisbury. This horizon will produce artesian or flowing wells. Its coarse strata are confined by the Sankaty clay beds on top (see Plate 18, Fig. 2), and while these gravels have no surface outcrop they are connected with the main ground water table by the porous Tisbury strata above at places where the clay sheet has been eroded. When the clay sheet is punctured the pressure is releast and an artesian flow results. The Jameco horizon is extensiv over eastern and western Long Iland. It is developt principally for purposes of public water supply along the south shore of the iland by the Brooklyn Water-Works and the Queens County Water Company.

This horizon is composed of glacial gravels, the outwash of an earlier glacier than the Wisconsin. The color is generally gray and the matrix contains considerable percentages of multi-colored stones, or erratic material. The section and record at the pumping station of the Queens County Water Company, Valley Stream (see Plate 23, Fig. 1), is typical of the whole south shore from that point east to Babylon. These sections will show the Tisbury water horizon near the surface, the Sankaty gravels and clay below the Tisbury, and then generally a sheet of lignite above the Jameco gravels. The top of the Jameco gravels will usually be found about 100 to 110 ft. below sea level, the well strainer, of course, being entirely placed in the water-bearing material.

As explained above, the Jameco water horizon is directly connected with the main ground water table thru breaks in the overlying clay sheet, and the water supply is large because of such connection, and also for the reason that the physical character of the gravels allows them to hold and retain the percolating waters. The waters from the Jameco, however, have this disadvantage, that where the water-bearing sands and gravels overlie the Sankaty blue clay and lignite beds, as they generally do, the percolating water from the upper water-bearing material causes the iron in the clay and

lignite beds to leach down into the Jameco gravels and impregnates them with a strong chalybeate odor and taste. Of course, in large operations where the Jameco water is mixt with the Tisbury this condition is not very apparent, but in the case of a private water company developing water extensivly from the Jameco gravel water horizon, it becomes necessary to filter out the iron.

Plate 27, Fig. 1, shows the pumping station of the Queens County Water Company. The picture shows the Jameco water being pumpt into the filter bed in the foreground.

The lignite beds underneath are peat beds, and, like all peat beds, contain bog iron ore. A blue or a slate-colored clay is an evidence that iron is present in the clay, hence this water will and does carry limonite (bog iron ore), $Fe_2 O_3 + \frac{3}{2} H_2 O$, in suspension.

The filter beds are gravity sand filters and the suspended iron forms in a crust on top. Unless this water is purified its presence forms red oxid of iron in the water pipes and becomes extremely annoying when used for domestic purposes.

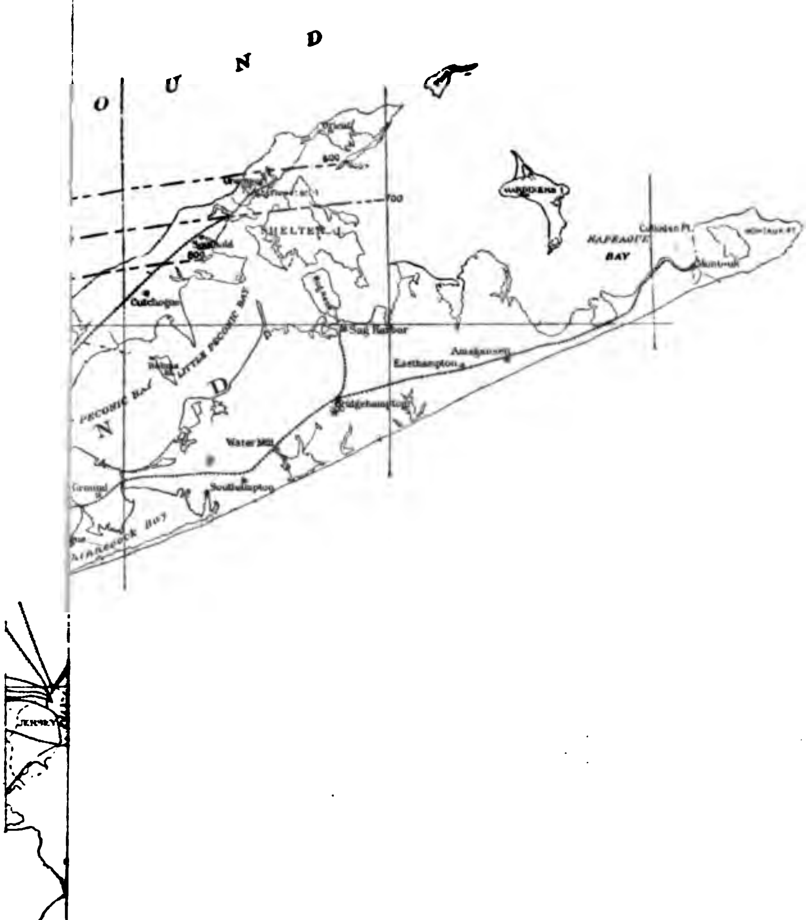
Plate 23, Fig. 1, also represents the formation of coal in the lignite or peat beds. The formation of coal and iron goes hand in hand, and we have here the coal measures and the iron mines of Long Iland in their initial stage of formation.

The Lloyd Gravel Water Horizon.

This is the deepest zone of flow on Long Iland. It is situated in the Upper Cretaceous sands and gravel above the bed rock (see Plate 18, Fig. 2), and is correlated to the Raritan formation in New Jersey. On the north shore this horizon has been developt considerably because its depth—200 to 400 ft.—is not excessiv, but on account of the dip of this stratum toward the south shore, the wells in that locality must be driven to a depth of 700 to 750 ft. to penetrate this horizon. This horizon will also produce artesian wells for the same reasons as the Jameco. On Barren Iland in Jamaica Bay is an example of such a well.

Plate 23, Fig. 2, is a section taken at Lake Success, which is situated about half way between Lloyd Neck and Coney Iland. (See Plate 26.) The top of the Lloyd sand is 660 ft. below the surface and 490 ft. below sea level. At Gay Head the lignite and red clay beds are 170 ft. above sea level. Here in this section they show 300

PLATE 26.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FARMER ON LONG ISLAND
UNDERGROUND WATER SUPPLIES.



and 400 ft., respectivly, below sea level. This record establishes the correlation between the deep Cretaceous wells on the north shore at Lloyd Neck, Center Iland, etc., and those on the south shore. This water horizon extends into New Jersey, and at Asbury Park its depth is about 1 100 ft. below sea level.

Mr. A. C. Veatch, of the U. S. Geological Survey, has plotted the contours of the top of Lloyd sand below sea level. (See Plate 26.)

The object in drilling deep wells in the Lloyd gravel is not to get an increase in head, but to find a coarse, free, water-bearing horizon.

The water of the Lloyd gravel is low in chlorine, hardness and alkalinity, and this horizon seems to be persistent and perennial. There is reason to believe that future developments in this material will produce large supplies.

The position of the section in the Lloyd gravel at Lake Success is markt in Plate 22, Fig. 2, as "deep well." Lake Success is a kettle-hole lake at the junction of the Harbor Hill and Ronkonkoma Moraines. It is situated high above the main ground water table and is an example of a percht water table. There are many such in the path of the moraines, but the water-sheds are limited and depend on local impervious strata to preserve their water level. The economic importance of percht water tables is small on account of their limited capacity and insular position.

Methods of Securing Underground Water Supplies on Long Iland.

Aside from the sources of supply due to lakes and ponds or from reservoirs impounding the flow of surface streams, from which it is no difficult problem to take supplies, there remains the vast underground water resources of Long Iland.

The task of securing plentiful and generous supplies from the underground water horizons is not an easy one. If the water horizons were laid down stratigrafically, each in a horizontal plane, so that sections taken vertically anywhere would show the same formation, then the problem of underground water supply could be readily solved. But this condition is not found on Long Iland. The water horizons have been generally distorted from their once

horizontal position, and it becomes necessary from the data of well-boring samples to plot the contours of the different water-bearing strata, in order to get an idea of the limits of any particular water-bearing area. The difficulty of locating the free water-bearing material for purposes of public supply is harder to overcome on the north shore of Long Iland than on the south shore, for on the north shore the Wisconsin drift is of considerable depth and has mixt its rubbish of boulders and clay with the Tisbury; but on the south shore the Tisbury water-bearing sands and gravels lie at or near the surface and can be more easily developt for water supply purposes. Most of the Tisbury water is pumpt by using a vacuum for lifting the water. The ground water table being near the surface, the merit of this method is at once apparent. Plate 29, Fig. 1, shows a typical layout of a well system water-works pumping from the Tisbury. The well strainers, preferably of brass, this being non-corrosiv, are placed in the water-bearing strata, and on the surface the well discharges thru a short pipe into the main receiving pipe. Each well is independent in the system, being controlled by its own well valve. Any well or group of wells can be shut off without interfering with the operation of the remainder. The discharge of the main receiving pipe is governed by a controlling valve, and the water passes into the receiver. Attacht to the receiver is the air pump and the pumping engine. The function of the air pump is to create a vacuum in the entire well system. This relieves the atmospheric pressure on the water in the wells and fills the receiver. The pumping engine itself is an efficient agent of the air pump in bringing the water from below the surface. The water passes thru the pump and is discharged into the force main at the required pressure.

Another type of well is the combination excavated and tubular well, shown in Plate 28, Fig. 1. A circular excavation is made below the ground water table, and a masonry shell or casing is sunk or bilt to some depth below it. In the bottom of this excavated well, tubular wells are driven and the strainers placed in a free water-bearing stratum. The level of the water in the excavated well will rise to the limit of the ground water table. A suction pipe from the pump is introduced. The reservoir part of the well serves for storage and for a water seal to the suction pipe. The

FIG. 1.—PUMPING STATION AND FILTER BEDS OF THE QUEENS COUNTY WATER CO., VALLEY STREAM, L. I.

FIG. 2.—ARTESIAN WELLS AND FLUME IN THE VALLEY OF FLUSHING CREEK, CITIZENS WATER SUPPLY CO.

influence of the pump is felt in all the tubular wells and draws the water upward from its underground position into the reservoir above and thence into the pump. This type of well will deliver large quantities of water. An example of such a well may be seen at Pumping Station No. 1, Long Iland City. While the influence of the pumping engine and the air pump produces satisfactory results in drawing water from the underground supply, there is a more powerful agent than these, viz., the air compressor. The duty of the air compressor is to furnish air under heavy pressure in the well pipe. The simplest method of using comprest air in lifting water is shown in Plate 28, Fig. 2.

The main air pipe runs from the receiver of the air compressor either on top of the flume or on its floor, and at each well it is tapt by a branch air pipe. This branch air pipe extends down into the well and is turned upward at the bottom. At each pulsation of the compressor a corresponding pulsation is made in the well pipe and the water is forced upward and discharges into the flume. It is evident that comprest air under heavy pressure is powerful and far reaching in its action in the water-bearing strata. It draws the water from remote places and compels its presence in the well pipe. The use of comprest air in lifting water adds greatly to the supply. An excessiv pressure may cause fine sand to be drawn thru the strainer and forced upward in suspension, producing subsequent damage to the pump valves.

The operation of this system is shown in Plate 27, Fig. 2. The flume is situated at the foot of the eroded side of the valley. The water table is at the surface, and, under normal conditions, these wells are flowing or artesian wells.

Under the influence of comprest air the water flows into the flume and thence into a receiving well, from which it passes thru the pumps and into the water mains.

This elementary method has been modified and improved for pumping from deep wells. (See Plate 29, Fig. 2.) The essential and governing principle in this type of air lift is that the air supply can be controlled in the well pipe itself. This is accomplisht by means of a valve in the air pipe in the well, these valves being regulated by a wheel at the top of the well head. The air can be admitted at variable water levels, a valuable consideration,

where several water horizons are penetrated. Especially valuable in the operation of deep wells in excellent water-bearing strata is the fact that the heavy head of water in the pipe, due to the presence of the ground water table, can be thrown off and the well compelled to draw for its supply from the lower and greater water horizon.

This principle is made use of in the operation of the Jameco Pumping Station at Jameco, Long Iland. The water is there being lifted from the deep wells in the Jameco gravel water horizon.

Another method of obtaining underground water on Long Iland is by means of infiltration galleries. The essential principle involved in this method consists in excavating a trench or tunnel below the level of the ground water table. By extending the gallery or ditch to a very considerable length, with a slope less than that of the surface of the ground, the underground water can be brought to the surface by gravity alone. This method can be applied generally only along the south shore of the iland, where the ground water table is near the surface and where its slope is appreciable. The ditch or collecting gallery is constructed across the path of the underflow, and the water drawn therein flows by gravity to a receiving well, from which it can be pumpt, or the water may be piped to a reservoir on the surface.

Conclusions.

A summary of the foregoing establishes the following facts: Long Iland and the ilands in the Sound or off the southern coast of New England have a common origin. The basal clays on top of the bed rock, created by erosion or corrosion from the rocks on the mainland, are covered by the sands, gravels and boulder clays, later brought down by the glaciers or from outwash from the terminal moraines of the glaciers.

The strata do not lie in conformity, and the clay sheet confining the lower water horizons has been broken or eroded away, producing the phenomena of flowing wells. The supply of water is dependent on the rainfall and gives rise to the presence of the ground water table which fluctuates vertically in proportion to said precipitation. The ground water table follows the topografy of the surface and its divide between the underflow toward the north and the south shore will generally be at about the same geografical position as the

PLATE 28.
THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.
FARMER ON LONG ILAND UNDERGROUND WATER SUPPLIES.

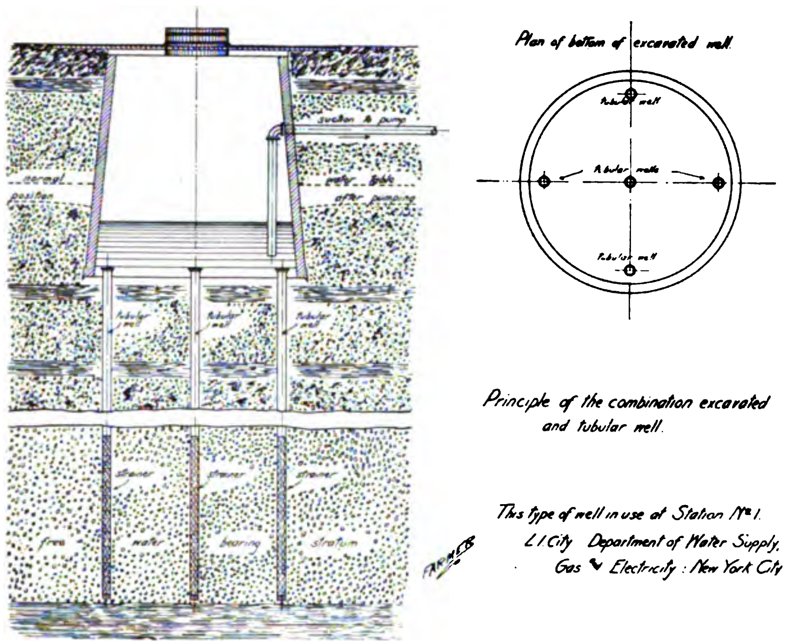


Fig. 1.

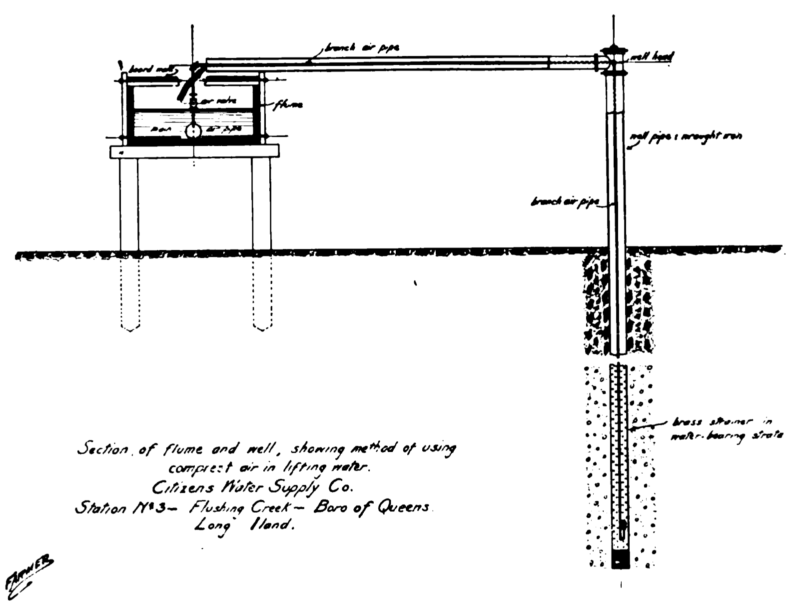


Fig. 2.

PLATE 29.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FARMER ON LONG ILAND
UNDERGROUND WATER SUPPLIES.

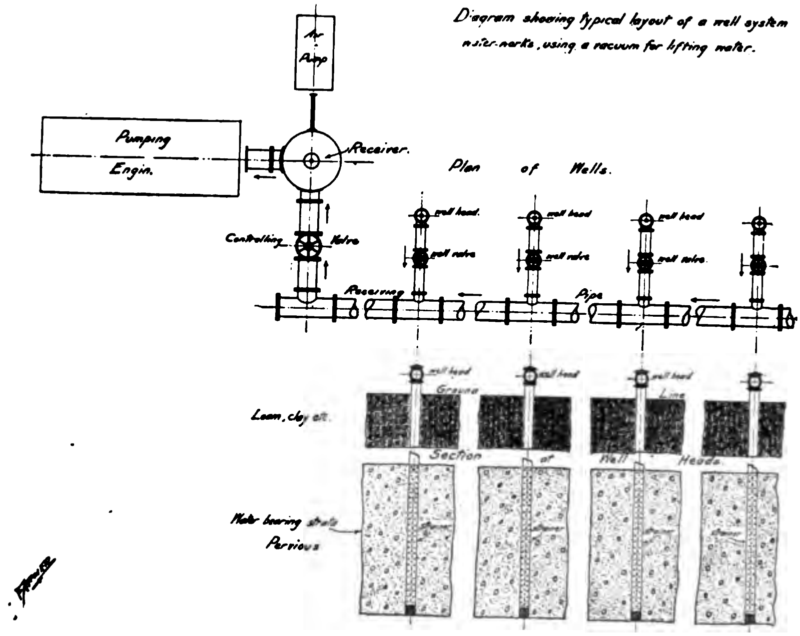


FIG. 1.

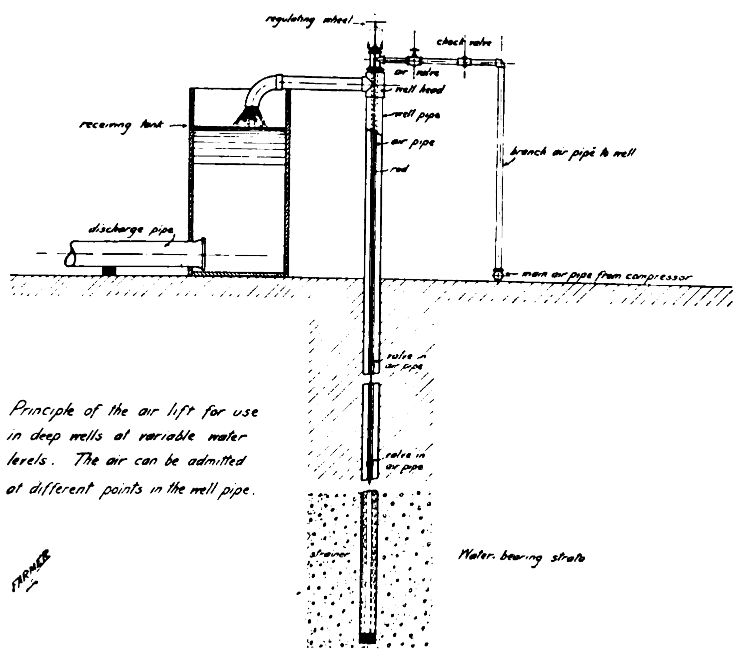


FIG. 2

divide of the surface waters. The soil being porous, there is little evaporation, and for the same reason a scarcity of surface streams, which not only carry the run-off, but at the same time carry away some of the water of the ground water table where the valleys or depressions cut it and cause its waters to flow into the stream. The importance of the natural wells or kettle holes in the Tisbury formation and also the excavated wells in the same formation, to which latter class the infiltration gallery belongs, is significant. The large area of the upper water horizon, and its nearness to the ground surface, makes possible a large supply of water by pumping from shallow wells. The waters of the Jameco gravel horizon, while of generous proportions, generally carry iron in suspension and should be filtered when necessary. The future development of the Lloyd gravel horizon should give large supplies.

The supply from the percht water tables is insignificant and only of local importance.

Attention is called to the ponding along both the north and the south shores and to the water wasting over the spillways of the dams; also to the decided artesian character of the waters along the north shore. Exploitation of this field should produce an abundant yield. The value of comprest air as an agent in expelling the underground waters is apparent.

The development of the infiltration gallery should become an important factor in enlarging the public water supply.

DISCUSSION.

MR. GEORGE S. RICE.—Gentlemen, you have all been very much pleased, I know, to hear Mr. Farmer, and I think there must be somebody who will discuss this question. I will call upon Mr. Brush, Assistant Engineer of the Board of Water Supply, who will, I think, have something to say in reference to subsurface conditions of Long Iland.

MR. WILLIAM W. BRUSH.—Mr. Farmer has given us the geology of Long Iland so thoroly that it is not necessary for me, nor would it be possible for me, to add anything to what he has given.

I think that probably you might be interested in the methods that have been used to develop the supply from the various gravel and sand strata for the use of the Boro of Brooklyn, which takes the greatest quantity of water that is drawn from Long Iland for a public source of supply.

The supply of the Boro of Brooklyn has been, as the majority of you probably know, as a rule, only slightly in excess of the consumption and at times less than the normal consumption, since about seven or eight years after the works were first installed. The earliest type of well that was used to increase the supply was the open well. The original supply was a gravity supply, collected in small ponds and delivered by a gravity condit to the main pumping station. In 1880 there were three of these stations where they had these large, open wells. The wells were 50 ft. in diameter and had brick linings, and were sunk so that the bottom of the well was perhaps 15 ft. below the water level. They did not yield a very large quantity of water, and if the water level was lowered to any extent, the sand, which is rather fine, would flow in. Those wells probably never yielded continuously more than three-quarters of a million to possibly a million gallons per day.

In about 1882, when Brooklyn had another shortage of water, the first one of the stations of the gang well type was put in under what was then a patented system owned by Andrews Bros. These wells consisted of 2-in. well points driven in the upper sand to a depth usually about 50 ft. below the surface, which would represent from 35 to 45 ft. below the ground water level. Those wells were composed of 2-in. cast-iron strainers, ribbed, so that the brass gauze covering which kept out the sand would have a maximum effectiv area for allowing the water to enter the well. The ribs came to practically a knife edge and therefore took up very little of the area of the brass gauze which surrounded it. These wells were usually driven in groups of anywhere from 100 to 150 wells, and were located about 12 ft. apart and on two lines parallel to the axis of the suction pipe. They were driven about 12 ft. from the

centre of the main suction pipe and connected up to this pipe, which was laid east and west of the receiver at the pumping station. The line of wells was driven at right angles to the line of flow of the underground water table. When first constructed, these stations would usually give anywhere from 3 000 000 to possibly 4 000 000 or 5 000 000 gal. a day. The first wells put in lasted for several years, the majority of them not having to be cleaned until 1894, or about ten years after they were driven. During this time there was a gradual clogging and filling in of the points until finally the flow was materially diminisht.

The first stations that were put in were the Spring Creek and Baiseleys Stations, which were installed under the same contract and which were located between Jamaica and Brooklyn. In 1884 and 1885, the Forest Stream and Clear Stream Stations were bilt, and in 1890-1892 the Jameco Station. These five stations were put in by Andrews Bros. under their patent.

After 1894, when there was another shortage in the water supply, additional wells were driven by various contractors and a number of stations establisht, so that at present there are 20 small stations which furnish a supply to Brooklyn from driven wells.

The wells used to replace the Andrews wells were 2-in. points, but simply had holes bored in the galvanized iron pipe, thereby giving a much smaller area for the water to enter the well, and the result was that they clogged more rapidly. While the original wells driven by Andrews had a life of some ten years, these last wells would only have a life of perhaps two or three years, and then they would clog so badly that they would have to be cleaned and in many cases pulled and redriven after cleaning. Sometimes it was possible to clean them in the ground by washing.

Subsequent to the use of 2-in. wells came the use of 4-in., 6-in. and 8-in. wells, which were of the same general character, except there was some variation in the form of strainer used. In each case, however, it was a framework of either brass or iron covered by a brass perforated screen. That perforated screen usually had openings which would be about .03-in. in width, so as to prevent sand other than the smaller sizes from entering the well. With the larger wells you could usually obtain from a system of, say, 12 or 14 wells, about as much as you would obtain with the earlier system of 100 to 150 of the smaller 2-in. wells.

The so-called deep wells were first developt for a supply in about 1896, altho a number of wells had been driven about five years earlier, and they are simply an extension of the shallower wells. The 6-in. or 8-in. pipe, usually with a strainer attacht, is sunk by means of turning, and washing or bucketing the sand from the pipe, and is carried down thru the clay to the sands below the clay bed.

These wells have yielded, when pumpt separately, as high as 1 000 000 gal. a day each.

Recently the water above the clay bed has been developt by means of a long, open drain. A central well, with a water-tight bottom, would be sunk to an elevation about —8 or —10 ft., or perhaps 10 ft. to 12 ft. below the water level, as the water level usually stands along the south side of Long Iland about 5 ft. above the tide in the vicinity of the supply streams. Then from each side of this central well would be laid an ordinary tile sewer pipe, with the joints left open and surrounded by gravel, so that the water would enter the pipe and flow by gravity to the central well, from which it could be pumpt into the condit and thence carried to the main pumping station. This would form an under-drain, and by laying the under-drain at a level at the central well of from — 5 to — 6 ft. and carried out to each side of the central well for a distance of, say, from 6 000 to 9 000 ft., the pipe would be laid to such a grade that the upper end would be about 2 ft. below mean high tide, the water flowing above the clay bed would be collected and carried into this drain by means of gravity and delivered to the central station. In this way you would accomplish two results. You would reduce the cost of operation by having a much larger quantity concentrated at the central station, and have a tile collecting pipe, which would not be subject to corrosion. The results from this form of construction in one station which has already been completed have shown that in ordinary dry weather the flow is about 1 000 000 gal. per 1 000 lin. ft. of gallery. In other words, where we have a 12 000-ft. gallery we can pump continuously at the rate of from 10 000 000 to 12 000 000 gal. per day, and that is developing only the supply above the clay bed. The same gallery can be used to develop the supply below the clay bed by sinking wells thru the clay and connecting them to the gallery. The hydraulic gradient in the gallery being usually below tidewater, the wells will flow freely, as the elevation of water in the wells before being connected would probably be 8 or 10 ft. above tidewater, giving, therefore, an available head of some 10 ft. for creating the flow.

Where the system of laying the suction mains on the surface has been used, and connecting the wells to the suction main, and then in turn from the main suction to the pump, a great deal of difficulty is experienced with the air which enters in minute leaks in the joints of the pipe and also to some extent in the wells. This air breaks the vacuum, so that the draft is mainly from the central part of the line of wells and the minimum draft at the end. Furthermore, it makes a very expensiv system to maintain, because you only have, say, from 2 000 000 to 4 000 000 gal. a day at a central station, and you have practically the same crew as you would have if you were pumping three or four times that amount.

The development of the water below the clay bed by excessiv pumping would probably in time result in a reduction of the flow above the clay bed, as the source of supply is essentially the same. By lowering the water level or hydraulic gradient below the clay bed you would induce a greater flow in time to that point and thereby you would be robbing—if I may use that expression—the supply which could be obtained from above the clay bed, which could be developt at a much less expense than the deep well.

The question of what form of development would be the most economical for a large population like Brooklyn's would be dependent, in the case where works already existed, upon the value of the works you would have to abandon in order to develop a new system of central station control. The supply could be pumpt from wells by having a central station with units at each well or small group of wells, or from a gallery or similar system. It is not a simple proposition to determin what is the best system of development where you have works already constructed, as has been the case in Brooklyn, on the watershed west of Suffolk County.

The latest type of well that has been developt for the Brooklyn supply has been essentially the gallery, turned up on end, or a tile well. This is bilt by first sinking a large casing, from 12 in. to 18 in. in diameter, to the level where it is desired to have the bottom of the well placed, and then lowering inside of this casing a tile pipe which has been slotted so as to allow the water to enter. The joints of this pipe are made with sulfur, or a mixture of sulfur and sand, and run as the tile are lowered, the tile being held by means of an iron rod with a plate at the bottom, on which the lower tile rests. After the tile have been lowered in place, gravel is dropt in around the tile and the casing gradually withdrawn, in that way creating a gravel cylinder around the well and preventing the entering of sand into the well except under very heavy draft. This type of well has been successful in its construction and use and is superior in many ways to the old type.

In addition to this type of well there has been proposed the "California" well, which essentially consists of a double line of short lengths of pipe made up of riveted steel. The first, or outer section, has telescoped inside of it a second section and the joint is simply a butt joint. Each section is 2 ft. in length, and the joint of the one section comes in the middle of the other section. This pipe is forced down by means of hydraulic jacks which are anchored to "dead men," the sand removed by washing or bucketing, and then the well is slotted at whatever depth the strata indicate as giving good results. The slotting is done by means of knives worked by a special device, so that the casing can be cut at any depth, and the slotting is done after the well is in place. This well seems to offer great possibilities

and it is being tested by the Board of Water Supply for the purpose of developing the supply of Long Iland.

I have given you a brief sketch of the system or systems that have been used to develop the supply for the Boro of Brooklyn, and, while none of them have been entirely satisfactory, the gallery system has given us apparently the maximum yield, with the greatest probability of a long life, and also with the least cost, due to the concentration of a comparativly large volume of water at a central station. We have not had an opportunity to test the cost of a central station transmitting energy to motors at the individual wells and this type of construction may prove the most economical.

MR. GEORGE S. RICE.—I do not think we appreciate in New York the ease with which we get the water from Long Iland. I recollect distinctly, nearly 40 years ago, when the first filter gallery was constructed in this country. It was bilt to get water from a river by sinking a long gallery well along the river, but did not work easily on account of the deposited silt, and then they adopted the driven-well system, which has since been so much developt in this section of the city.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 32.

PRESENTED APRIL 24, 1907.

SOME NOTES ON MUNICIPAL CLEANING, AND REFUSE DESTRUCTION.

BY MR. JOHN TURNEY FETHERSTON, MEMBER OF THE SOCIETY.

WITH DISCUSSION BY
GEORGE S. RICE, FRED L. STEARNS, WALTER G. ELIOT AND LOUIS L. TRIBUS.

Municipal cleaning or street cleaning forms an important branch of city work. It has not generally been considered as an engineering subject, tho it is significant that engineers have been in charge of those departments in this country where most advances in the art have been made, while in Great Britain, municipal cleansing (so termed) is usually under the direction of the boro engineer or surveyor. The recent appointment of an engineer as head of the Department of Street Cleaning in this city is a recognition of the value of engineering management in this regard.

Health is not usually spoken of as an ideal state, yet the normal condition of life is that of disease. "Life is a struggle for existence, and only the fittest survive," is a familiar phrase. Hygiene is the science of health with reference to the individual or the family. Sanitary science concerns the health of the community and its principles and methods cover a broad field in municipal affairs.

Disease may be defined as a derangement of the bodily organs or tissues, whereby their functions are impaired. Zymotic diseases, such as malaria, diphtheria, typhoid fever, influenza, yellow fever, tuberculosis, smallpox, etc., are those due to infection from

without the individual. They cause about one-third of all deaths in this country. They are preventable, and mainly concern that branch of sanitary science classified as sanitary engineering.

Zymotic diseases are caused by germs called bacteria, which are very minute cells of organic matter, whose functions are always connected with changes in organic materials so as to be either useful or harmful in effect. Aerobic bacteria are those generally useful organisms which require oxygen for the performance of their functions in changing organic matter into harmless constituents, while anaerobic bacteria require little or no oxygen to perform their work. In this class are included most of the bacteria which produce putrefaction. Wherever filth and decay exist, bacteria, both useful and harmful, are always present in countless myriads, so that disease therefrom may be communicated to man by various agencies, such as air, water, food, clothing, dust, insects, etc. Hence, in so far as municipal cleaning from a sanitary point of view is concerned, the object to be attained is the prompt removal and final disposition of the solid organic waste of a city not removed by sewers, in such a way as to obviate the cause or prevent the spread of germ diseases.

While sanitation is the main feature of municipal cleaning, it is often found desirable to combine other branches of municipal activity under this head. Thus, in Richmond, street cleaning is under the direction of the Boro President, and the Bureau of Street Cleaning has the following classes of work in charge:

The cleaning or sweeping of streets, avenues and public places; the collection, removal and final disposition of all household, trade and street refuse; the removal of snow from roadways, crosswalks, sidewalks and gutters; the spreading of ashes, sand, etc., on slippery roadways; the light repairs or patching of macadam streets; the removal of encumbrances; the care and maintenance of the boro stables, and other minor classes of municipal work.

In any scheme of municipal cleaning there are three requisits for success:

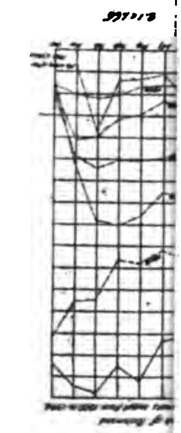
FIRST.—A sufficient appropriation.

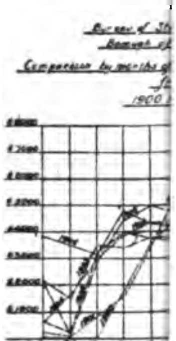
SECOND.—An efficient organization.

THIRD.—Sanitary and economical methods of work.

The first essential is self-evident, and requires no comment.

PLATE 30.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FETHERSTON ON MUNICIPAL
CLEANING AND REFUSE
DESTRUCTION.





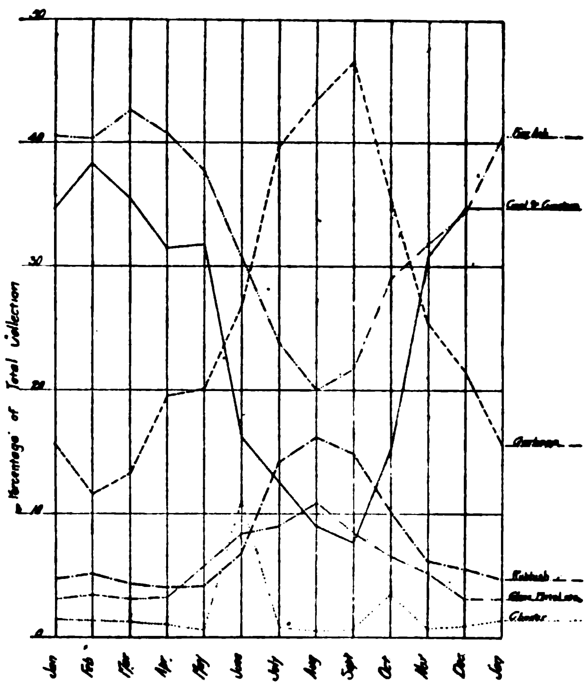


Diagram Showing Monthly Variations in Components of Household Refuse by Weight.
West New Brighton District

FIG 5.

A whole paper might be written on the subject of efficient organization alone, so that only a few salient points will here be noted:

Individual responsibility for work assigned is necessary. Employes should be paid for work performed instead of hours of labor. Several rates of pay for one grade of work will prove desirable. Efficiency records of employes individually, of sections under foremen, and of districts under inspectors or superintendents will create a healthy rivalry and conduce to better work. A cost-keeping system will more than pay for the clerical work involved. Vacations for all yearly employes, from laborers upward, with extra time off for men of high standing, will prove beneficial. Regulations governing appointment, promotion and the conduct of employes are necessary, tho punishment by deducting pay for violations of the rules of the service will be less effectiv than loss of vacations.

The third requirement, "sanitary and economical methods of work," will obviously depend to a great extent on the money available and the organization existing. Neither a standard of sanitation nor a standard of economy exists at present in municipal cleaning work. With regard to methods of work, the writer purposes to discuss the sanitary requirements and costs of some work in his charge.

Street Cleaning.

The prompt removal of filth, dirt, dust and rubbish from public places is a never-ending job. Strictly, the city should be required to clean up and remove only such material as results from the legal use of the public thorofares. Perhaps the most sanitary cleaning of paved streets is done by the use of water, where such is available and can be used. The method of flushing by hose from hydrants or by vehicles containing water tanks under pressure of comprest air is in successful use. The latter method is said to be more economical in the use of water, tho heavy pressures are liable to injure the pavement. Unless sewers are designed to carry off refuse, it is necessary to remove heavy materials by sweeping before washing streets.

Of the various methods of sweeping, a combination of machine work by night with hand sweeping by day has proved satisfactory on paved streets in Richmond Boro, tho the shortage of water for

sprinkling results in discontinuing machine sweeping to a great extent, especially in the warm weather.

The cost of street sweeping depends upon many factors, such as the character of the street, the kind and condition of the pavement, the presence or absence of street or elevated railways, the amount of traffic, and such special conditions as the bilding of sewers, laying of water mains, condits, etc.

The accompanying diagrams (Plate 30, Figs. 1, 2 and 3) give some information regarding the quantity, total cost and unit cost per mile for a combination of machine and hand sweeping of streets averaging 30 ft. between curbs, including all classes of pavement, tho macadam predominates. In spite of an increase of from 12% to 16% in wages for sweepers and foremen in 1904, the unit cost of the work has decreast, due to the effect of a cost-keeping system and an efficiency record of employes.

The littering of streets with paper, rubbish, etc., is much more common in New York than in English cities. Rubbish may not be unsanitary in itself, but a littered street is most unsightly. Ordinances prohibit the throwing of materials into the public thorofares, but the police seldom arrest offenders. It would seem that the only way to keep the streets clear of litter is by providing a large number of small receptacles at convenient points, by arresting violators of ordinances and by gradually educating the people to higher civic standards.

Snow Removal.

The polluted condition of the atmosphere in and around cities is well attested by a snowfall, which filters the air and causes a precipitation of dust and germs which may later give rise to various diseases. Thus, the sooner snow can be removed from city streets, particularly in crowded districts, the less liability will there be of disease. Prompt clearing of snow from the main thorofares of a city where the snowfall is so variable as in New York is indeed a serious problem when the means available are considered. Apparently the only practical way of removing and disposing of snow at present is by haulage to nearby waters or vacant property.

Plate 30, Fig. 4, gives quantity and cost of snow removed from a small area in Richmond for a number of years past. Carts and

PLATE 31.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FETHERSTON ON MUNICIPAL
CLEANING AND REFUSE
DESTRUCTION.

FIG. 1.—STABLE B, WEST NEW BRIGHTON, N. Y.

FIG. 2.—STABLE A, TOMPKINSVILLE, N. Y.

laborers are hired for the work, which is under direction of inspectors, assisted by extra foremen from other bureaus of the Boro President's office. The cost of removal is variable, depending upon weather conditions, length of haul, state of the labor market, depth of snowfall, etc.

In addition to the removal of snow from streets by emergency gangs and some regular employes, sweepers clear crosswalks, open gutters, remove snow from about hydrants and clean sidewalks if the property owner fails to remove snow therefrom within four hours after the storm ceases. The cost of sidewalk work, plus a fine of $3, becomes a charge against the property, and owners generally manage to clear away the snow when they know that the ordinances will be strictly enforced. In Richmond, it was necessary to clear walks of only 1 075 pieces of property on 70 miles of roadway in 1906 at a cost for labor, supervision and clerical work of 16½ cents per city lot.

Spreading Ashes, Sand, Etc., on Roadways, Crosswalks and Sidewalks.

This is protectiv winter maintenance work which has a value that cannot be measured in dollars and cents. Preparations are made before winter sets in by storing steam ashes at convenient places near paved roads so that sweeping-cart drivers may readily scatter the material on icy streets. Each sweeper cares for his own section and uses ashes from nearby houses for slippery sidewalks and crosswalks. Sand, macadam screenings and grits are sometimes used in place of steam ashes, as they create less dirt, but the cost is much higher and the benefits questionable. About 1 000 cu. yd. of steam ashes were spread on slippery streets, crosswalks and sidewalks during the winter of 1906 at a total cost of $1.45 per cu. yd.

Light Repairs.

Macadamized streets predominate in Richmond, so in 1903 gangs of laborers from the Bureau of Street Cleaning were assigned to the patching or light repair work on macadam roads. This system was changed in 1904 to one of continuous maintenance, whereby sweepers were required, not only to clean, but also to repair mac-

adamized streets. Most repair work is done in wet weather when pools of standing water indicate the depressions, which are filled with stone and bonded to the old macadam by traffic. It is found that this method is much more economical than gang work where picking and watering are required, and, if the traffic is heavy enough, wet weather patching gives surprisingly good results. Only a portion of the roads in Richmond Boro are cared for in this manner.

Boro Stables.

Two stables (A and B) are in charge of the Bureau of Street Cleaning. Seventy horses in all are cared for, including draft horses for the street cleaning service and the Bureau of Sewers, and light driving horses for various other bureaus in the Boro President's office. Plate 31, Fig. 1, shows type of stable.

Refuse Collection.

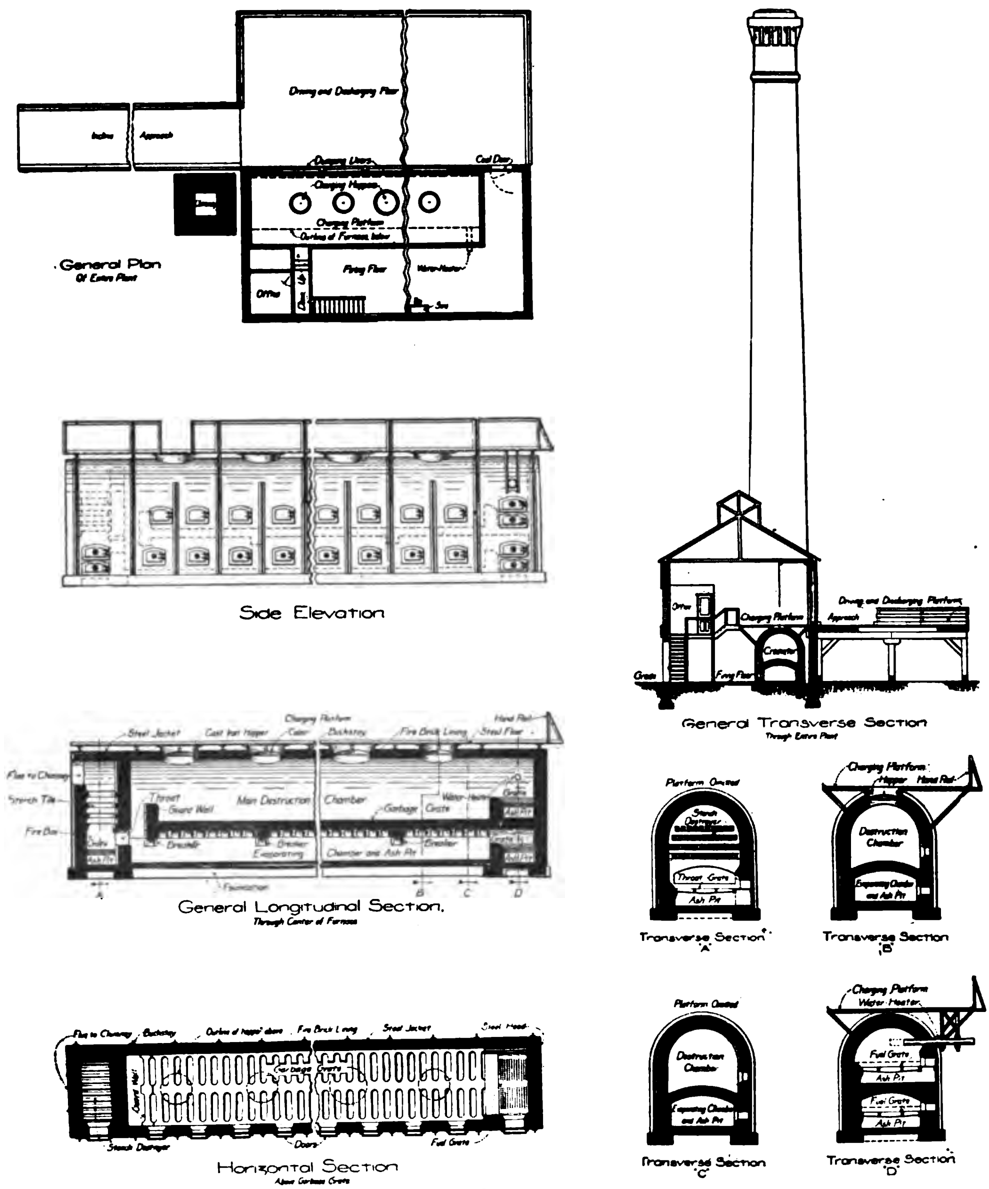
A daily collection, prompt removal and rapid final disposition of household, trade and street refuse is the most important duty devolving on a municipal cleaning department.

The collection of refuse is performed either by general contract, by hired carts or by the municipality direct. In 1904, the hired cart system for the greater portion of Richmond Boro was succeeded by municipal carts, with some conflicting results with respect to costs, as Table No. 1 indicates:

Table No. 1.

Year.	Ashes, cubic yards.	Garbage, cubic yards.	Rubbish, cubic yards.	Street sweepings, cubic yards.	Total refuse cubic yards.	No. of houses collected from.	Total cost of collection.	Cost per cubic yard.	Cost per house, per annum.
1904	53 791	19 096	4 379	38 896	116 162	7 738	$47 635.37	$0.41	$6.16
1905	34 012	19 110	9 750	33 728	96 600	9 499	54 939.68	0.56	5.78
Difference in favor of hired carts, 1904	19 779	....	......	5 168	19 562	......	$7 304.31	$0.15	......
Difference in favor of city carts, 1905	....	145	371	....	....	1 761	....	....	$0.38

PLATE 32.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FETHERSTON ON MUNICIPAL
CLEANING AND REFUSE
DESTRUCTION.



Dixon Crematory.

Evidently the amount of refuse collected by the hired carts was overstated; thus the unit cost per cubic yard is in their favor, but the city carts served a much greater number of houses at a less cost per capita, which is really the better comparison.

With regard to complaints of non-removal of refuse, Table No. 2 gives an idea of the better service rendered by city carts:

TABLE No. 2.

			Cause of Complaint.		Result of Investigation.			Action Taken.	
	Year.	No. of Complaints.	Refuse not removed.	Miscellaneous.	Cart driver at fault.	Complainant at fault.	No cause for complaint.	No ground for action.	Driver found guilty and fined.
Hired carts....	1904	131	115	16	35	56	..	24	10 fines
City " ...	1905	81	79	2	11	24	14	32	3 "
" " ...	1906	61	55	6	16	15	30	13	4 "

In both tables, the districts covered were about the same and the population served amounted to 60 000.

Hired cart drivers gave unsatisfactory service, the carts were unsanitary, and the change to municipal ownership and operation of the service has been justified both from a sanitary and economical standpoint.

Any method of refuse collection (including removal) is dependent upon the system of final disposition, and the two (collection and disposal) form one problem which concerns the engineer more than any other kind of work in municipal cleaning.

It is the general practice in this country to separate garbage from inorganic wastes and either burn it in a garbage crematory or treat it by the reduction process where any scientific method of disposal is used. Thus steel carts of the type common in New York are suited to the sanitary collection of garbage. In Great Britain, all household refuse is mixt, and most cities burn it in a so-called destructor. As household refuse weighs only about 1 000 lbs. per cu. yard, wagons of large-capacity are suitable and economical.

The question of economical collection of refuse has not received the attention it deserves, and it will be found that the cost of collecting the refuse is generally two or three times the cost of disposal. Thus, with long hauls, there is little dout that wagons of large capacity will prove more economical than carts. With respect to a daily collection, mixt refuse can usually be removed more economically than separated materials, tho comparativ lengths of haul may reverse this conclusion.

Final Disposition.

Since 1895 the problem of the final disposition of household refuse has been under investigation and trial by different authorities in Richmond. Garbage crematories have been erected and have proved unsatisfactory in settled localities. A system similar to the Brooklyn method of transportation by electric street railway to an outlying property where garbage and perhaps rubbish would be burned, and the ashes used for filling, was under consideration, but it failed because no satisfactory type of crematory was found which promised to deal with the garbage in a sanitary and economical way, and also as the street railway company put so high a figure on the cost of transportation that the scheme was deemed impracticable. Reduction was out of the question because of the small population and long hauls.

Some method of disposal was required, however, and a thoro study of the whole subject was begun in 1904. Available technical publications were summarized, and it appeared that the method used in Great Britain might solve the problem, provided the mixt refuse contained sufficient combustible material to burn itself at a temperature high enough to obtain complete combustion, thus preventing nuisance. No definit information was available on this point, so it was decided to analyze the waste materials (see Plate 30, Fig. 5), determin their calorific value and carry out practical combustion tests, so that if the English method proved unsatisfactory there would be at least a collection of data which might serve as a basis for other possible methods of disposal.

As a result of the various studies, analyses and tests, however, it was determined beyond a reasonable dout that mixt refuse de-

PLATE 33.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FETHERSTON ON MUNICIPAL
CLEANING AND REFUSE
DESTRUCTION.

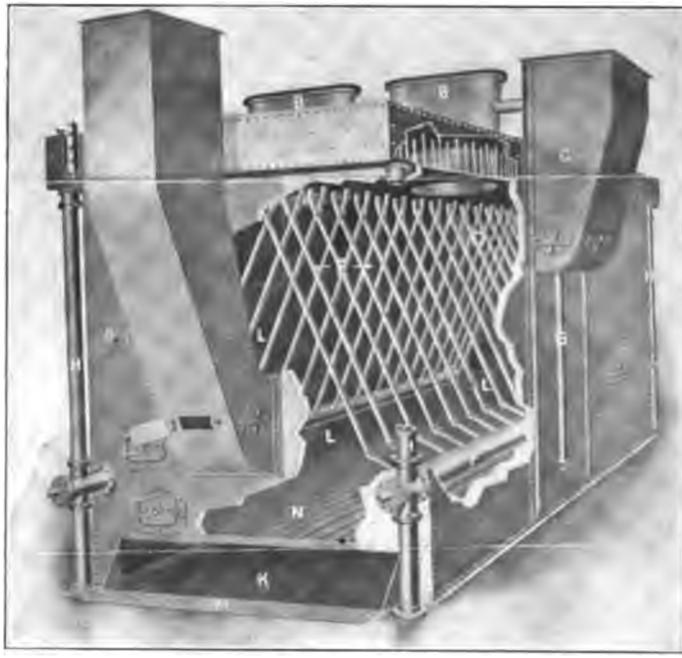


FIG. 1.

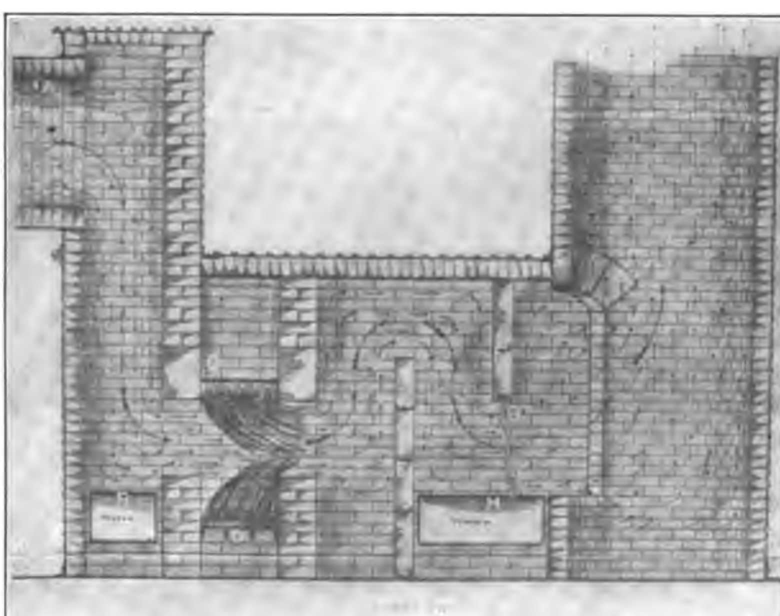


FIG. 2.—DECARIE GARBAGE AND REFUSE INCINERATOR WITH GAS-CONSUMING CHAMBER.

PLATE 34.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FETHERSTON ON MUNICIPAL
CLEANING AND REFUSE
DESTRUCTION.

VIEW SHOWING LOCATION OF HERMAN DESTRUCTOR AT RATHMINES, IRELAND.

PLATE 35.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FETHERSTON ON MUNICIPAL
CLEANING AND REFUSE
ESTRUCTION.

Interior View of a Modern English Destructor.

struction would prove satisfactory and would be advantageous in the following respects:

1. It would keep the cost of collection and removal at a minimum, as the plant could be operated without nuisance within the district served. This advantage would be permanent.

2. It would be sanitary and final in its disposal, as all household refuse, including ashes, garbage and rubbish, could be past thru the furnace and the residue rendered innocuous.

3. It would abolish ash and rubbage dumps, which are always sources of nuisance, especially in summer, because a large portion of the public will not completely separate the organic from the inorganic wastes. As nearby dumping places became filled, hauls would be lengthened, so that the separation system would always tend to increase the cost of collection, while the mixt refuse destruction should rather tend to decrease in cost with increase in population.

4. The by-products resulting from the destruction of mixt refuse might be employed to reduce the cost of the process. Steam power is produced, and can be used for various municipal purposes, such as lighting, pumping water, pumping sewage, etc., while crusht clinker mixt with cement serves for making slabs, bricks, etc.

5. Mixt refuse should save much trouble to the householder, as but one receptacle would be required, and the ashes would tend to deodorize and retard decomposition of the garbage, thus preventing odors from garbage cans. This would be of special advantage during the warm season.

Comparison between methods of refuse disposal should be made on the basis of sanitary efficiency, or, in other words, only equally sanitary systems should be compared. In this respect, and after full consideration, mixt refuse destruction was recommended for adoption in Richmond. The writer was then instructed to visit Great Britain and examin various types of destructors for the purpose of verifying reports and determining the most suitable designs for adoption.

The illustrations accompanying this paper show sections and plans of two types of American furnaces. Views of bildings and surroundings of English installations are also given, so that the permanent character of the plants and their location may be compared.

As a result of the studies and examination of British plants, a contract has been signed for the erection of a destructor at West New Brighton. This destructor should be in operation before the end of the year, and then more definit information as to costs, etc., will be available on this departure from general American practice in the final disposition of household refuse.

DISCUSSION.

MR. GEORGE S. RICE.—About ten years ago there was a young man working with me as one of my assistants in Boston and one day he said, "Mr. Rice, I have had an offer to go to New York. Col. Waring has askt me to go there and commence work with him." That young man is here to-night and he has been in that department ever since. Mr. Stearns, I think, has some lantern slides and has something to say.

MR. FRED L. STEARNS.—The subject of disposition of refuse has been a vexing one. Mr. Fetherston has had the same problem to meet in the Boro of Richmond as exists in the other boros, only differing in its form to suit the conditions of each boro. The investigations he has made and the data he has collected will aid others who are determining the means by which they will dispose of their refuse.

Some information concerning the work of the Department of Street Cleaning in the boros of Manhattan, The Bronx, Brooklyn and Queens of this city may also be of value. Let us consider this subject under the following headings: Cleaning of Streets, Collection of Refuse, Stables, Dumps, Scows, Disposition of Refuse and Snow Removal.

CLEANING OF STREETS.

The streets are cleaned by hand, with sweeping machines and flusht with water. In hand sweeping a certain number of blocks are assigned to each sweeper. These he is expected to keep clean from 7 A. M. until 4 P. M., excepting for one hour at noon, which he has for luncheon. This route varies in length from about four hundred feet to one mile, depending on the amount of traffic, the width of the street, the habits of the people in the neighborhood, and whether the route is or is not near unpaved streets. The sweeper's outfit consists of a can-carrier, push scraper, push broom, short-handled shovel, and, during the summer months, a hand sprinkling can. It is his duty, upon arriving on his route, to go over the same quickly, and pick up the litter, such as paper, pieces of wood, excelsior, etc. If his route is on an asphalt street, he goes over it with a push scraper, and the remainder of the day he is expected to keep it as clean as possible, using the most suitable implement he has for accomplishing this result. If the route be one with a stone block pavement, then the push broom is the principal thing used.

While snow is on the pavement, the sweeper's duty is to keep the crosswalks clean, the gutters open, so that water, either from the melting snow or from a storm, can have free access to the

sewer catch-basins, the snow cleared away from the fire hydrants, the litter pickt up and the streets swept as soon as conditions permit.

The sweeper is required to wear a clean white uniform and a white helmet. There are 2 434 sweepers employed in the boros of Manhattan, The Bronx and Brooklyn. On streets where there is a large traffic and the can-carrier is a serious obstruction or the can on the curb is a nuisance, the sunken can receiver is used to a good advantage. The sweepings are placed in a can under the sidewalk. When the can becomes full it is removed and emptied into a cart. There are 1 018 miles of paved streets in the three boros mentioned. Many of these are swept several times a day.

Sweeping machines are used in the suburbs, where there is little traffic, and on the streets that need cleaning but a few times a week; also on some of the streets near stables, dumping places, etc., where the sweeping is heavy, to help the street sweeper keep his route clean. A watering cart goes before the sweeping machine during the warm months to lay the dust.

Many devices for sweeping and picking up the sweepings have been tried, but, as yet, have not proved satisfactory.

Each day, when the temperature will permit, many miles of streets are washt with water, a hose being used at times. This method is objectionable, as it uses a large amount of water, the hose obstructs vehicles, and the water is apt to wet pedestrians passing on the sidewalks. Unless the man holding the nozzle is very careful, while working on a busy street, the stream at times will go in directions not intended, causing considerable annoyance.

The flushing machines use less water and can work at any hour of the day, as they pass along with the traffic while flushing the street. In the best arranged machines the flushing goes on under the wagon.

Collection of Refuse.

The city collects nearly all the refuse. The ashes and garbage are collected separately, but with the same style of cart. The ideal ash and garbage cart is one that will hold the proper sized load, is water-tight on the sides and bottom, strong and light, that will tip at the dumping boards, that will prevent the ashes from being blown about the streets when loading and going to the dumping places, and is a sanitary wagon for the garbage.

The driver is assigned to a route, the average length of which, in the bilt-up portions of the city, is one mile. He is required to remove the ashes, garbage and street sweepings on his route. The garbage is collected between certain hours in the morning and the ashes and street sweepings during the remainder of the day. The

ashes are put outside the house in one can and the garbage in another.

The paper cart is a large box-cart with slats above the regular body, making it have a capacity of 8 cu. yd. The driver of this cart collects the light rubbish along his route. Each house is supplied with a "P and R" card, which is displayed in a place where it will be easily seen by the driver. The displaying of this card means that there is light rubbish in the house for which the driver is to call.

There are 1 375 drivers in the three boros mentioned. All drivers wear a brown uniform, a brown helmet in summer and a brown cap in winter. Their horses travel an average distance of twenty miles each day.

Automobile ash trucks have been designed, but no bilder would construct one unless he had a contract with the city, and the city does not enter into contracts for devices that have not proven satisfactory by actual use.

Stables.

The Department either owns its stables or leases them. The stables are designed to give plenty of light and fresh air and are equipt with the best sanitary plumbing. The floors are either of cement, with wooden slats under the horses, or of well-calked yellow pine. The slats under the horses are movable and the floor is flusht every day. There are twenty-one stables used by the Department. The one now about completed on Flushing Avenue, Brooklyn, is not only a stable, but an office, storage and repair bilding as well.

Dumps.

The dumping boards at the water fronts are about 18 ft. above high water, with an approach 18 ft. wide, having a grade not exceeding 8%. The overhanging portion extends 13 ft. Each board is 70 ft. long, which is less than the distance between the bulkheads on the scows, thereby allowing the bulkheads to rise above each end of the dumping board at extreme high tide. At one of the dumping boards a cover has been bilt and has proved to be quite an advance in both appearance and convenience.

The ideal covered dumping board is one in which the scow can also come inside the structure, so that the dumping of the contents of the carts upon the scows can be performed under cover. Such a dump consists of two piers, with a space for scows between, and a cover over all.

Scows.

Flat deck wooden scows are the most suitable for removing the refuse from the water-front to the places of disposition. The

garbage goes to Barren Iland reduction plant, where it is unloaded by hand upon a conveyor. The ashes and the portion of the rubbish not incinerated goes to land fills, where it is unloaded by dredging buckets. The refuse dumpt at sea is unloaded by hand.

The standard sized scows are 110 ft. long, 30 ft. wide and 9 ft. from deck to bottom of scow.

Disposition of Refuse.

There are now being disposed of each year over three million loads of refuse collected from the boros of Manhattan, The Bronx and Brooklyn. A chart showing the number of loads collected in the boros of Manhattan and The Bronx from 1895 to 1904 is of interest. The hight of each column represents the total number of loads collected for each year and the subdivisions show the loads of ashes, rubbish and garbage as indicated. During 1895 there are no subdivisions, as all material was collected in a mixt condition, in carts of 1½ yd. capacity. During a portion of 1896 the material was collected in a mixt condition, but for the remainder of the year it was collected separately. The quantity of garbage is therefore small. The quantity of rubbish is quite large, considering that it was collected separately for only part of a year. This is due to its being collected in the regular-sized cart of 1½ cu. yd. capacity and to the fact that the refuse is bulky. We know, therefore, that during 1895 a large proportion of the material was rubbish, tho mixt with the other refuse.

During 1897 the large increase in garbage is due to its being a full year's collection, better separation of material, together with the regular yearly increase. The rubbish for this year decreast when it should have increast. This is due to the change in the size of cart from 1½ cu. yd. capacity to 4 cu. yd., thus decreasing the number of loads. A part of this decrease is also due to the increase in value of the light rubbish, it being kept separate by the housekeepers and collected by private cartmen for private use.

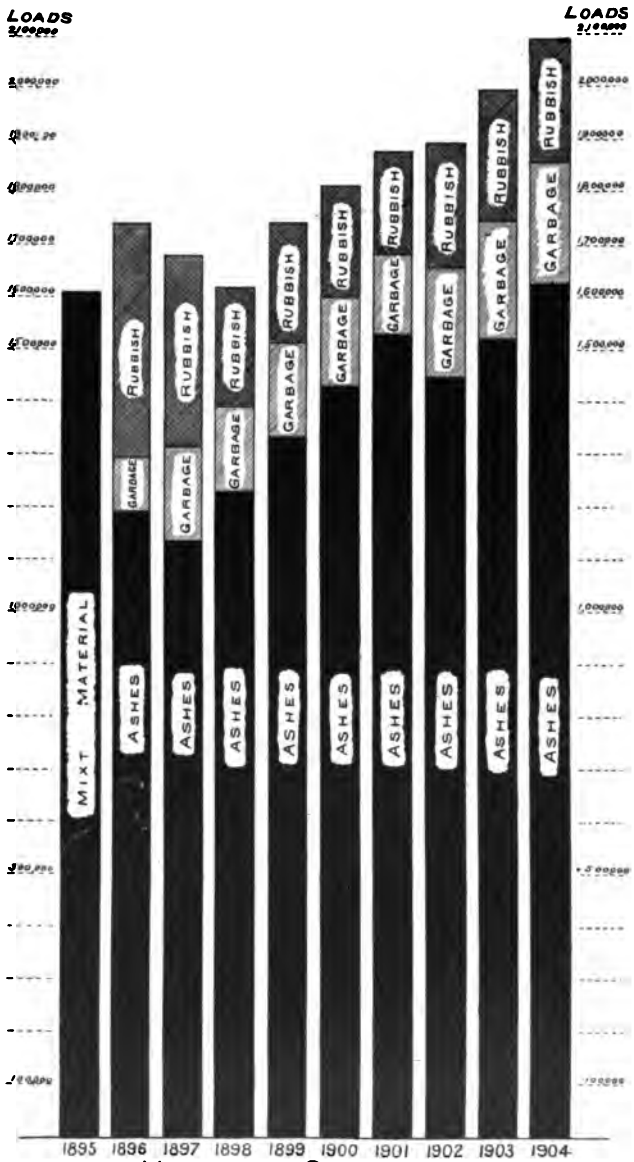
From 1898 to 1904, inclusiv, the total number of loads of material collected increast each year. This number of loads is also affected by a gradual increase in the size of the rubbish cart to a capacity of 8 cu. yd.

In the boros of Manhattan and The Bronx there was collected during 1905 2 177 388 loads; during 1906, 2 313 285 loads, and during 1907, in the boros of Manhattan, The Bronx and Brooklyn, 3 122 598 loads.

This material was disposed of by sea dumping, land filling, reduction and incineration.

Sea Dumping.—All material was formerly dumpt at sea. A tug towed several scows far beyond Sandy Hook, so that by un-

PLATE 36
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FETHERSTON ON MUNICIPAL
CLEANING AND REFUSE
DESTRUCTION.
DISCUSSION BY STEARNS.



MATERIAL COLLECTED
IN THE BOROS OF
MANHATTAN and THE BRONX

F L S

loading at the beginning of ebb tide the floating material was supposed to be carried to sea and not return. The winds, however, would often blow this floating material back upon the beaches.

Land Filling.—Many a low land has been raised to a proper level with the city's refuse. Some lots are filled by the carts dumping the refuse directly on the low land; some by the refuse being transported from central loading stations in large receptacles or trolley cars and the refuse dumpt by means of electric apparatus on the land.

Other low lands are filled in by refuse that is transported on scows and unloaded by means of buckets upon cars or by a conveyor that dumps the refuse directly onto the land to be filled in.

Reduction.—The garbage consisting of animal and vegetable matter is reduced by the Sanitary Utilization Company. This company furnishes the scows, tugboats and labor for removing the garbage from our dumping boards along the water front to their plant at Barren Iland, where it is reduced. The contract price for removing and reducing as above stated for the Boro of Manhattan is $148 000 a year, and in the year 1907 187 924 loads were collected and disposed of. A load of garbage weighs about 1 750 lb.

At the Barren Iland plant the garbage is cooked in large digesting tanks until the oil and grease particles are dislodged. By means of hydraulic presses the liquids are then removed. The oil and grease are sold, to be used in the trades. The remaining solid material from the presses is dried, ground and used as a base for fertilizers.

Incineration.—When Col. George E. Waring, in 1895, caused the ashes, rubbish and garbage to be collected separately, it was his intention to incinerate all the rubbish that was not salable. The following will show what has been done in the incinerating of rubbish.

Col. Waring had an incinerator bilt in East Eighteenth Street. It was quite a complete plant. There was a furnace, a conveyor, a boiler, a dust catcher, a fan, an exhauster, an engin, etc.

While the refuse on the conveyor was passing to the furnace all salable articles were removed. Steam was generated in the boiler, which furnished all the power needed at the plant. There was an auxiliary furnace for burning the bulky rubbish. This saved the labor of breaking up large barrels, boxes, furniture, beds, etc., they being thrown into the furnace just as they arrived at the plant.

From 40 to 50 loads were disposed of at this plant a day, which continued in operation for several years, until the lease of the property expired.

Four Dixon's garbage furnaces were bilt in the Boro of Queens,

which burned the garbage and rubbish of that boro. In one year 5 617.6 tons of garbage and 687.3 tons of rubbish were burned. In addition to this rubbish there were 626 tons of coal and 12 tons of cord wood used to help burn the garbage. This wood and rubbish is equal to 139.8 tons of coal. Therefore, 766.1 tons of coal were needed to burn 5 617.6 tons of garbage. One pound of coal burned 7.3 lb. of garbage. These furnaces have been kept in repair and are still in operation. The combustion is slow and at a low temperature.

An experimental garbage furnace was bilt by the Department in West Fifty-first Street. A test was run for 15½ hr. and 6 099 lb. of wet garbage were burned. The amount of coal burned was 720 lb. One pound of coal burned 8.5 lb. of garbage. The garbage was reduced to 5.6% ash, not including the ashes from the coal. No rubbish was burned at this plant, as the information desired was for garbage alone.

A rubbish furnace with two 50-h.p. boilers was next constructed by Major John McGaw Woodbury, Commissioner of Street Cleaning, under designs of Mr. H. de B. Parsons. This plant was for the incineration of rubbish and for experimenting with steam production.

A Decaric furnace was then bilt by a contractor for burning the garbage of The Bronx at East One Hundred and Forty-fourth Street. This plant was run for several days and was then obliged to shut down, as it failed to do the work.

Major Woodbury said the same as did Colonel Waring, that rubbish is good fuel and only requires the proper furnace in which to burn it.

A small experimental rubbish plant was later constructed at North Moore and Varick Streets by the Department. A test was run for 6 hr. and 3 324 lb. of rubbish were burned; 24.6 lb. of rubbish per hour produced 1 h-p. An average of 22.4 h-p. was produced. There was 40 sq. ft. of grate and 13.8 lb. were burned per square foot of grate per hour. The heating surface of the boiler was 324 sq. ft. The horse-power to a square foot of grate was 0.56. The heating surface to 1 sq. ft. of grate was 8.1 sq. ft. One pound of rubbish evaporated 1.5 lb. of water.

After finding that the rubbish had such a high fuel value, it was decided by Commissioner Woodbury to alter the West Forty-seventh Street plant and put in another boiler of 150 h-p. capacity, so as to make the plant a more efficient steam producer.

When completed, a test was run for 4½ hr.; 23 011 lb. of rubbish were burned. The grate surface was 154 sq. ft. An average of 232 h-p. was produced. One pound of rubbish evaporated 1.59 lb. of water; 14.5% was ash. A cubic yard of rubbish weighed 111 lb.

PLATE 37.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FETHERSTON ON MUNICIPAL
CLEANING AND REFUSE
DESTRUCTION.
DISCUSSION BY STEARNS.

FIG. 1.—ASH AND GARBAGE CART.

FIG. 2.—RUBBISH CART.

The heating surface of the boilers was 2 759.9 sq. ft. There were 17.9 sq. ft. of heating surface to 1 sq. ft. of grate. The horse-power to 1 sq. ft. of grate was 1.51; 21.9 lb. of rubbish per hour produced 1 h-p.

The steam power produced could not be sold, and there was no way known to utilize this power by the city.

The following measurements were made on the light rubbish at West Thirtieth Street Dump:

Eighteen loads weighed, on coal scales, 19 040 lb.; measured in carts = 125¾ cu. yd.; average load, 1 058 lb. = 7 cu. yd.

Weighed on small scales in measured boxes:

Mixt paper pickt..........	5 366	lb.	67½	cu. yd.
Bottles "	272	"	½	" "
Iron "	71	"	¼	" "
Barrels "	1 170	"	13	" "
Total pickt............	6 879	"	81¼	" "
Waste	9 382	"	69½	" "
Total disposed of.......	16 261	"	150¾	" "

Decrease in weight by second weighing, 2 779 lb. or 14%.

Increase in bulk by second measurement after sorting, 20% or 25 cu. yd.

Percentage pickt, 42% by weight, 54% by bulk.

Percentage of waste, 58% by weight, 46% by bulk,

Another measurement at West Thirtieth Street Dump:

Twenty-four loads, weighed on coal scales, 21 790 lb.; measured in carts = 161¾ cu. yd.; average load, 908 lb. = 6.7 cu. yd. Weighed on small scales in measured boxes:

Mixt paper pickt.........	6 515	lb.	88½	cu. yd.
Bottles "	213	"	½	" "
Iron "	420	"	3	" "
Barrels "	1 440	"	16	" "
Total	8 588	"	108	" "
Waste	10 879	"	92¾	" "
Total disposed of.......	19 467	"	200¾	" "

Decrease in weight by second weighing, 2 323 lb. or 10%.

Increase in bulk by second measurement after sorting, 24% or 39 cu. yd.

Percentage pickt, 44% by weight, 54% by bulk.

Percentage wasted, 56% by weight, 46% by bulk.

At West Forty-seventh Street Dumps, loads measured in carts and weighed on coal scales:

44 Department loads	48 100 lb.	33¾ cu. yd.
10 Private loads	4 530 "	39 " "
Total	52 630 "	373¾ " "
Average Department load	1 093 "	7.6 " "
Average private load	453 "	3.9 " "

Weighed on small scales in measured boxes:

Newspaper pickt	5 184 lb.	98 cu. yd.
Manila paper "	1 250 "	54½ " "
Pasteboard "	4 909 "	105 " "
Mixt paper "	2 613 "	53 " "
Rags "	1 007 "	6½ " "
Mixt rags and paper pickt	625 "	6 " "
Iron and tins pickt	1 942 "	16 " "
Bagging "	184 "	1 " "
Carpets "	274 "	1½ " "
Barrels "	2 826 "	31 " "
Books "	259 "	½ " "
Bottles "	363 "	½ " "
Shoes "	186 "	½ " "
Hats "	17 "	½ " "
Rope "	111 "	½ " "
Boxes "	1 400 "	11 " "
Total pickt	23 114 "	372 " "
Waste	24 275 "	218½ " "
Total disposed of	47 389 "	590½ " "

Decrease in weight by second weighing, 5 241 lb. or 10%.

Increase in bulk by second measurement after sorting, 58% or 216¾ cu. yd.

Percentage pickt, 48.8% by weight, 63.0% by bulk.

Percentage of waste, 51.2% by weight, 37.0% by bulk.

Commissioner Woodbury having ascertained by actual tests that rubbish was a good fuel and found out by actual measurements by weight and by bulk the quantity of valuable articles obtainable, decided to bild a plant under the Williamsburg Bridge, with a conveyor for sorting the material and with boilers for the production of steam. The plant was designed by Mr. H. de B. Parsons. The conveyor traveled along the lower floor, then up at an angle to the

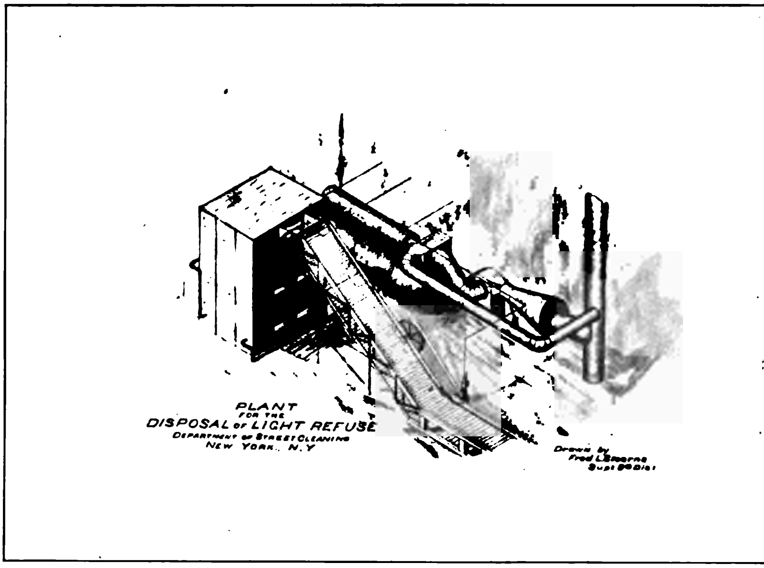


FIG. 1.—COLONEL WARING'S INCINERATOR AT EAST 18TH STREET, N. Y.

FIG. 2.—INCINERATOR AT 37TH STREET, SOUTH BROOKLYN, N. Y.

FIG. 1.—SORTING REFUSE FROM BELT CONVEYOR AT WEST 47TH STREET, N. Y.

FIG. 2.—INCINERATING FURNACE AT DELANCEY STREET, N. Y.

top of the furnaces. There were large storage spaces on both lower and upper floors. There were chutes from the upper floor to the conveyor, so that material stored on either floor did not have to be moved on an average of more than 18 ft. before it went on to the conveyor.

There were two furnaces and two 200-h-p. Sterling boilers, with feed-water heaters.

A test was run for six hours and much more efficient results were obtained than with previous plants, owing to the furnaces being nearer to the boilers, and to the longer distance the heat traveled thru the Sterling boilers and feed-water heaters.

In six hours, 40 497 lb. of rubbish were burned, developing an average of 455 h-p. The grate surface was 172½ sq. ft. The heating surface of the boilers was 3 900 sq. ft.; 14.8 lb. of rubbish per hour made 1 h-p. One pound of rubbish evaporated 2.29 lb. of water; 39.2 lb. of rubbish was burned per square foot of grate per hour; 2.63 h-p. was developt per square foot of grate per hour. There were 22.6 sq. ft. of heating surface to a square foot of grate; 14.9% of the quantity burned was ash.

The temperature in flue between the furnace and the boiler was 2 900° fahr., found by the use of segar cones.

The average weight of a cubic yard of rubbish burned was 138 lb.

The plant began by furnishing about 250 amperes at 250 volts, and lighting only a part of the bridge. The load was increast until 800 amperes at 250 volts were generated, lighting the whole bridge.

This increase in demand for power caused the plant to be run beyond its reasonable capacity, melting the firebrick in the flue to the boilers. This portion of melted brick, together with ashes and other elements carried from the furnace in suspension, filled the flues with a slag like iron ore, while the melting brick gradually disappeared, until the top of the flues caved in and the plant was obliged to discontinue lighting the bridge and simply run for the incineration of rubbish. A contract was then made with the Edison Company for lighting the bridge at the rate of 3½ cents a kilowatt hour.

Another furnace has been bilt close to the boiler without any flue between the two, but the opening between the two is the full width of the boiler and furnace. This has been run for nearly a year, producing the steam to run the conveyor and presses, without any repairs, melting of brick or production of slag.

After making the calculations it was found that with all the improvements made it would, however, be impossible to generate electricity for 3½ cents a kilowatt hour, and the matter of lighting the bridge was given up.

The plant has been arranged simply for incineration of rubbish, and is doing excellent work. The waste heat goes up the stack.

Another furnace was constructed at the foot of Thirty-seventh Street, South Brooklyn, without a boiler. It has been found to be very economical. It has run for nearly two years with almost no repairs, and the only city employee at the plant is the man who tallies the loads. A contractor operates the plant for the privilege of sorting and picking out articles of value.

The failure of the incinerating plant to light the Williamsburg Bridge does not prove that rubbish is not a good fuel. Neither does it prove that it is impracticable to generate steam power with rubbish as a fuel. Only twelve years ago this burning of rubbish alone was untried and today we are not only trying to compete with coal-burning plants of the same capacity, but with the large plants of the Edison Company.

Snow Removal.

When the snow has fallen to a depth of 2½ in. a contractor commences to remove the snow, following a schedule furnisht him by the Department. The street sweepers keep the crossings cleared and shovel the snow out of the gutters and away from the fire hydrants. The Department carts haul a few loads of snow each day, besides their regular work of refuse removal.

Mr. W. G. Eliot.—I would like to ask a question. Mr. Stearns has brought up a proposition to us New Yorkers.

I met Colonel Waring in the University Club the first night he was nominated for Street Cleaning Commissioner and asked him: "Mr. Commissioner, isn't that a sort of graveyard for every man's reputation who has previously attempted it?" He said: "Well, I'll clean a square yard of this city and keep it clean, and as long as the money lasts I'll keep another square yard clean"; and he did it on that principle, but he put brains and engineering principles into it from the time he began.

Last winter I was wondering at the operation of the Street Cleaning Department in one of our finest streets—Eighty-sixth Street. They had a dump for the snow there. That, of course, in the winter, is the problem, getting rid of snow and ashes at the same time. They started to clean Fifth Avenue and Madison Avenue, and the car lines attempted to clean their respectiv tracks north and south. They attempted to carry the snow, mixt with whatever ashes and other things that were thrown into it, from Madison Avenue and dump it off the dock at Eighty-sixth Street. They drove their carts over unremoved snow for the five or six blocks intervening. It seems to me there is no engineer that

FIG. 1.—CHUTE AND DIGESTORS AT BARREN ILAND REDUCTION PLANT.

FIG. 2.—PRESSES AT BARREN ILAND REDUCTION PLANT.

would run a private business for any length of time on that theory. He would have started at the other end and cleaned off a path for his wagons to pass over. The question came to my mind, "Isn't this done by a contractor entirely out of control of the city?" That is a question which I want to ask Mr. Stearns, who seems to be a thoro and practical man. Here was a crowd of people in a densely settled portion of the city, throwing their ashes into the street, because they were left there day after day for want of carts. The wagons coming with the snow from Madison Avenue, Fourth Avenue, Third Avenue, etc., for removing which they were paid, drove down over the ashes and snow and hardened them into a mass that for weeks after could not be removed with a pick. Is not the contracting company which is, for private reasons and for private gain, removing the ashes over the trolleys in Brooklyn, in the conveyances described a few moments ago, doing the work that the City of New York ought to do in the Boro of Manhattan? Where does the engineering common sense come in of carting material over stuff which you have to dig up and cart off afterward? The consequence is that for almost the entire winter—which, of course, everybody admits was a very severe one—great areas were left with nothing but masses of dumpt ashes, which were finally, at the request of somebody in the Street Cleaning Department, removed. They askt for the privilege of washing it away with a hose. What was the result? Within six hours five sewers in that section were stopt completely. The contracting firm that dumpt the snow off the dock at East Eighty-sixth Street were in trouble right away with the War Department, which informed them that they were filling the channel. The ashes which they had dumpt there, mixt in very large proportion with the snow, had been deposited below and was filling the deepest portion of the channel in the swiftest portion of the East River. I would like to ask, what is the cure for this and how can people in such a district, without exciting the enmity of the Street Cleaning Department, succeed in having the place relieved of ashes under such circumstances? The district superintendent and section foreman in that neighborhood are both good friends of mine, and I gather a great deal of information from them. They do as well as they can.

Some months later I was present one day when a delegation, headed by Henry Robinson, of the dry goods district, came to Colonel Waring and said: "Can't we have our section cleaned over here, in the dry goods district? We pay taxes there and pay large taxes." "Yes," said Colonel Waring, "and what proportion of the taxes do you think you pay? The area to be covered is very great. I'll tell you what I'll do, sir. Poor people probably pay about as large a proportion of taxes as you gentlemen do down

there, and they need their streets cleaned the first thing. I'll clean theirs off first and then come down to your place."

MR. FRED L. STEARNS.—There are many amusing problems connected with the Street Cleaning Department. Was that East Eighty-sixth Street, or West?

MR. W. G. ELIOT.—East.

MR. FRED L. STEARNS.—That is my old district. I was there from 1895 to 1898, and we did some good snow work up there in 1898, if you can remember that particular year. With respect to commencing at Eighty-sixth Street and East River, removing snow there first, and working westerly to avoid carting over the snow, I can say that I was not allowed to do that, because there were people all thru Madison, Fifth and Third Avenues demanding that the Department remove the snow from their districts. The car tracks were open there, so we could drive down Eighty-sixth Street with the load.

We cannot commence down at the dumps first; we have to commence where the people must have it removed. You know a great deal of trucking is done in certain districts. There is a great deal of fruit and meat coming into the city, and when we have a large snowstorm we have to remove it first from the most important places. The telephone rings and a voice says: "There is going to be a wedding in Seventy-eighth Street, near Fifth Avenue, to-night and we must have that block cleaned at once."

In regard to dumping ashes in the streets during or after a snowstorm: At such times nearly all the officers are away on snow duty and the sections are left in charge of men not familiar with the work. At such times fewer loads can be hauled per day, because of the hard traveling for the horses. The ashes accumulate and the cans become filled, so the people dump their ashes in the streets. The ashes on the snow prevent it from melting, and this snow and ashes thus mixt must be dumpt upon the scows at a much increast cost, because the Department is not allowed to dump ashes into the river.

The system of trolley removal in Brooklyn is not applicable in Manhattan, because here we have such a short run to the water front. In Brooklyn it is so far that such a system is possible. It is a question in my mind whether even there it is not cheaper to go back to the carting system. It seems very nice, but when it comes down to dollars and cents we find that that is what we have to consider.

MR. L. L. TRIBUS.—I think, Mr. President, that as the hour is late I will not attempt to say much of anything. I do not think I could add very much to what has already been said on this subject.

The question of street cleaning and refuse disposal is one of

our pet hobbies in Richmond. Five years ago we started with a department of two hired sweepers and a handful of laborers, and, I believe, about thirty carts, and practically nothing else except the broken-down Dixon crematory, which has been illustrated. We now have clean streets. We don't have any boxes and barrels or rubbish along the streets. We have good-looking carts, well-equipt stables, and hope to have one of the best refuse destructors ever planned under construction within the next few weeks. If our hopes are realized, about the end of this year or the early part of next year we may be able to come here again and give you some further statistics and facts as to the result secured in burning mixt refuse, all classes of waste material. We have great hopes, but we may be cast down.

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.

Paper No. 33.

PRESENTED MAY 22, 1907.

THE RELATION OF SANITARY SCIENCE TO MUNICIPAL ENGINEERING.

BY MR. GEORGE A. SOPER, PH. D., MEMBER OF THE SOCIETY.

WITH DISCUSSION BY

MAX L. BLUM, GEORGE S. RICE, AND THE AUTHOR.

It would be interesting, if space permitted, to inquire into the nature of the specific causes of infectious diseases and especially of those which must be considered in the laying out of a city. We should see that the principal diseases to be avoided are those which are propagated by microbic germs and that these germs are transmitted from person to person with the excretions of the body. We should find that, before the nature of these infectious poisons was understood, theory, based purely upon imperfect observation, pointed to filth, foul odors and exhalations from decomposing matters as spontaneous sources of disease. It is necessary here merely to mention this fact and to point out that, altho the prejudice of uninformed persons sometimes causes them to lean to the old pythogenic, or disease-breeding, theory, the fight against typhoid and other epidemic diseases, to be effective, must be a fight against germs which always originate in human bodies and are thrown off with human excretions.

This means that there is nothing occult or mysterious about the diseases which municipal engineers need consider. Science has no longer any faith in the fatal potency of miasmatic vapors, mephitic exhalations, gaseous evolutions and other dogma, which were the bugbears of pioneers in municipal sanitation. The day is fast

coming when it will seem as grotesque to ascribe infectious disease to gases or vapors as it would be now to say, as was customary once, for example, that John Doe died of megroms, that Mrs. Doe was planet-struck, or that Colonel Brown was liver-grown.

This is not saying that filth is not objectionable, that garbage, slush and offal should be allowed to remain in the streets. Sanitary science emphatically protests against these conditions. But it is saying that we should regard a nuisance as a nuisance, not cry wolf without reason, and, above all, not obscure the real causes of disease by entertaining conceptions which have no foundation in fact.

Filth favors disease, but does not breed it. Low standards of municipal housekeeping encourage low standards of domestic housekeeping. Where people are careless with wastes which are offensiv to the eyes and nose, they are careless with those which are dangerous. Filth, therefore, often encourages the spread of disease, if it does not actually produce it.

As to the effectivness of modern sanitation, there can be no dout. The general death rate in all civilized countries has been constantly falling in the last hundred years, and since about 1870 its decline has been remarkably steady. In the State of Rhode Iland, the average age at death has increast over five years in the last forty years. The smallest death rate which occurs anywhere is recorded in that country which is the acknowledged leader in sanitation, England. There only 152 deaths occur per year in every 10 000 of population.

It cannot be claimed, of course, that municipal sanitation has alone been responsible for the reduction in the death rate, for life has also been made safer because of advances in the knowledge of medicin, surgery and on account of better housing conditions. Nor must we assume from the improved condition of cities and the reduction in the death rate that the lessons of sanitary science have all been learned. One cause of death, which is to a great extent amenable to control by municipal public works, still figures largely in the returns. This is typhoid fever, a perfect example of the filth diseases of the dark ages. Typhoid is, like the poor, always with us. As far as can be judged from the defectiv statistics of the United States, it is about three times as prevalent in America as in the northern countries of Europe, Russia excepted. In our most

sanitary communities, typhoid fever usually claims from 15 to 20 victims per 100 000 of population every year while, in cities where standards of municipal sanitation are low, it sometimes raises the death rate to twenty times this figure.

The exact extent to which typhoid can be controlled by sanitation is not known, for the reason that no cities are perfectly sanitary. Furthermore, other sources of typhoid undoubtedly exist than those which are amenable to control by engineering works. But it is perhaps not too much to expect that in time this disease can, with improved sanitation and energetic board of health work, be reduced to less than one death in 10 000 of population annually.

It seems strange that any enterprising American city should be a chronic epidemic center and that the cause of this sickness should be clearly understood and not removed, but many such cities exist. Of the minor places whose statistics can be relied upon as accurate to within about 10%, 43 had death rates from typhoid fever of 100 or more in 100 000 of population in one or more of the five years between 1901-5. The persons sick must have been at least twelve times this number. How excessiv this death rate is may be judged from the fact that the Manhattan Boro of New York had a rate of 13.0 in 1905.

The most essential sanitary features of the modern city, so far as engineers are concerned, lie in the completeness of its water and sewerage systems, and especially in the ways in which the impurities carried in the one are kept out of the other.

In recent years much attention has been given to the scientific aspects of water purification, with the result that the leading factors which make for successful engineering design in plants of this kind are now fairly well understood. Engineers are rapidly coming to the view that all drinking water from surface sources must be purified, but this conclusion cannot yet be accepted without certain reservations. Experience shows that some surface water supplies exist which can be sufficiently protected by sanitary supervision of their drainage areas to warrant an indefinit postponement of the time when water purification will be necessary.

If it be asked under what circumstances a water supply can be kept pure, it must be replied that the subject is a large one and many considerations make it necessary that each situation should

be considered separately. But in a general way it may be stated as a guide to a safe conclusion that surface supplies should be filtered—(*a*) when the drainage area from which the water is derived is densely populated; (*b*) when a village or other settlement is located within a few miles of the intake; (*c*) where important manufacturing interests exist on the drainage area; (*d*) where the laws applicable to the sanitary protection of the supply are not favorable to the water-works; (*e*) where the collateral advantages of water purification, for example, clarification, are desirable in themselves; (*f*) where protracted storage is not feasible.

The purification of sewage is sometimes advocated as a measure of equal value to filtration for the protection of public water supplies, but it is not as reliable a means of excluding dangerous matters as it at first sight seems to be. The possible sources of defilement on a populated drainage area are likely to be far too numerous and too scattered and accidental for this method of protection to be all sufficient. Scientific sewage purification may greatly reduce the danger of typhoid and other diseases produced by water impurities, but it cannot keep out all wastes. Some of the greatest epidemics of modern times have been produced by water contaminated with germs which have been thrown upon the ground with typhoid excrement and have been washed into the supply by the rain. Plants for the purification of sewage are most useful when employed in combination with other measures of conservancy.

But if sewage disposal cannot rank with water purification in insuring a city against typhoid fever, it nevertheless has a very important field of usefulness in another direction. This lies in its power of ridding sewage of the matters which cause it to putrefy and produce offensiv odors in the streams and other places where all drainage must at last be discharged. There is no degree of purification which cannot be accomplisht by works for the sanitary disposal of sewage. It is only a question of expense how completely the impurities shall be removed. Contrary to a general impression, the manurial properties of sewage can very rarely be made to bring in a profitable return.

Turning now from branches of municipal engineering, in which there has been much profitable experience and in which certain methods of procedure are fairly well defined, to a matter of great

interest which is still in a primitiv state of development, we may briefly consider the methods and ends of street cleaning.

No work could be more unsatisfactory to contemplate from the engineering standpoint than this. The method of disposing of kitchen slop, ashes and other household wastes not capable of being carried away by a sewerage system are unsatisfactory in every city in this country today, and, what is worse, there seems no likelihood of early betterment. Nearly all of our cities are dirty with wastes which could and should be removed. In our northern cities large quantities of garbage and ashes accumulate thru the winter without any serious effort being made to carry them away, and in southern cities they are sometimes conspicuously offensiv the year round. This remark is not made from an ultra-æsthetic standpoint. We should all notice and object to the dirt if we were not so used to it.

As has been said, there is usually nothing activly dangerous about these wastes, as there is about the microbes in public water supplies and sewerage systems, but inasmuch as they offend the eyes and nose and contribute to disorder in a city they should be promptly carried away. Nothing better illustrates the fact that we have not yet learned what we need to know about sanitation than the placid way in which we place overflowing garbage barrels in front of our houses, soak our feet in filthy street slush, and breathe dust which is obviously little else than desiccated horse manure.

The trouble is not that engineers are incapable of handling the street cleaning question, but that they are so seldom given an opportunity to do so. It is not so long since an engineer was appointed Street Cleaning Commissioner of New York and made such a success of his office that he became a reproach to practically every other street cleaning commissioner. And yet what did Waring do? He introduced no ingenious mechanical methods of collecting the wastes, nor did he devise any new system for finally disposing of them. The city was put to no great expense for plant or labor. What Waring did first was to raise the force of men in the Street Cleaning Department from a mass of despised and almost disreputable laborers to an army of self-respecting and relativly industrious men. He showed that the task of keeping the city clean must be shared by everybody, and co-operation on a scale

never before or since witnessed in this city he secured to this end. Waring, with more than ordinary knowledge of the principles of his profession, taught the public that they would be sanitary if they were sane. It was neither sanitary nor sane to throw papers in the streets or to cast garbage out of the windows, to put ashes and swill on the sidewalk in pasteboard boxes and to indulge in various other performances with the consequences of which the people of New York had long been familiar.

Better carts and better ways of using them were employed. An effort was made to provide shorter hauls. The men were put in uniform and drilled. Records were made of the number of square yards of pavement of various kinds that a man with a broom could keep clean in the city under different circumstances of vehicular travel and each man was required to do a fair day's work.

The public was taught to separate its wastes and to place them convenient for the city collections under circumstances which made for economy and dispatch. Waring was apparently getting ready to do something substantial in the way of disposing of the wastes when his career ended.

The problem of street cleaning, as handled in Europe, bears no necessarily strict relation to the way in which it must be done in America. In Europe, city wastes are different in composition and in quantity. The labor, which is a particularly important element to consider in this work, is more satisfactory in Europe and the sanitary conditions are much less difficult to control.

The garbage, ashes and other refuse are usually collected together in English cities and generally destroyed by incineration in furnaces. Ocasionally these refuse disposal plants develop considerable efficiency as power producers, but in this direction, as in all sanitary lines, it must be remembered that the main object to accomplish is the inoffensiv disposal of the wastes. Engineers are frequently employed in Europe to design works to destroy the material collected in cleaning cities, but they have rarely been called on for such work in America.

In America, garbage and refuse have been extensivly employed for filling low lend in the environs of cities, the work being usually carried on without much regard for the comfort of the people in the vicinity of the dumps. It is true that in some cities this method

of disposition has been followed without the slightest inconvenience to anybody and with results which have been fairly satisfactory from an economical standpoint. But, in general, it may be said that this line of municipal sanitation is at the present time in a very rudimentary stage.

So far as mechanical methods of disposing of wastes are concerned, so-called reduction plants have occasionally been used in America to dispose of kitchen slop. This process consists essentially in the extraction of the grease by means of heat and pressure. The work is always done by private concerns who make contracts with cities by which the public pays to get rid of the waste. This method is so familiar to the people of New York City that further comment on it is unnecessary.

In the foregoing remarks attention has been directed to three principal lines of municipal engineering which, because of their prominence, are particularly interesting and receive a large share of attention. With these questions are associated other engineering problems, many of which are of scarcely less importance from the sanitary standpoint. The construction of streets with respect to route, width, design, pavement and underground conditions has much to do with health. The principal cities of Europe, most of which were once walled and greatly congested, have within recent years expanded into districts which are now notable both for healthfulness and convenience. The location and design of parks to relieve the most congested centers of cities, provisions for playgrounds and other opportunities for recreation have long been urged as sanitary necessities. The protection of harbor waters from defilement by sewage is a recent illustration of the growing importance of applying sanitary science to municipal engineering.

And there is a still more important matter which urgently calls for notice. This is the question of city transportation, the greatest problem to which municipal engineers have been called to devote attention within recent years.

It has been demonstrated in New York and elsewhere that it is impracticable to bild bridges, subways and surface transportation lines fast enough to afford proper transportation to the enormous numbers of people who want to travel to and from the business districts.

Anticipating the convenience to be afforded by the opening of new routes, arrangements are made by the public for residences and business headquarters along those lines. The ultimate effect is to more and more congest the business district and overtax the carrying capacity of the railways.

The remedy for this condition of affairs is generally thought to lie in providing more transportation facilities, and this no doubt is correct so far as present conditions are concerned. But in solving the problem for the future there are those who believe that it will soon be desirable to consider the possibility of restricting the capacity of the roads to what is safe and decent.

If it be objected that it would be difficult to enforce a limit to the number of people carried by each car, it may be replied that this is precisely what is being done in nearly every city in Europe.

The sanitary importance of this matter of overcrowding can scarcely be exaggerated, and engineers in responsible charge of designing subways, tunnels and other lines of railway where large numbers of persons are to be carried in small space should not overlook it. No amount of ventilation is capable of overcoming the dangers of overcrowding. The problem to be solved is not one of ventilation, but of contact.

Respiratory diseases are now the leading cause of death in our largest cities, and it is known that they are always produced by bacteria which pass from the throats and lungs of infected persons to the throats and lungs of others. It would be difficult to devise more perfect opportunities for transmission than are offered in overcrowded cars. Here people are gathered together, not merely as they are crowded in theatres, churches and other places of assembly, nor as is common on steam railways, but jammed in as closely as it is physically possible for human beings to stand.

They talk, cough and sneeze in blissful ignorance of the fact that every explosiv syllable from the lips shoots hundreds of invisible droplets of moisture into the air, each droplet perhaps loaded with deadly microbes. The man who stands talking with his friend, their faces only a few inches apart, bombards him with bacteria, and the strap hanger discharges a shower of germs directly down into the faces of persons who think they are fortunate in having a seat. To persons who are well out of range this is all

very humorous, but to many persons it is sometimes fatal. This is no exaggeration of the conditions. The data to support them are abundantly recorded in the literature of sanitary science.

It may be asked, if the germs of disease are so easily transmitted, why is it that great epidemics do not take place? As a matter of fact great epidemics do take place, but the diseases which they carry are so common that they scarcely attract attention.

The annual average number of deaths from diseases of the respiratory system in the registration cities of the United States in the five years 1900-4 was 464.0, while that of smallpox was 4.6. We may well agree with the philosopher Beddoes, who points out in his eleventh essay called *Hygeia*, "the folly of making such an outcry about the appearance of a mad dog and such a parade over the recovery of the drowned when we neglect calamities more frequent than the one and more terrible than the other."

It would, of course, be nothing less than Utopian to hope to see the work of municipal engineers always conducted along lines of which the most advanced knowledge of sanitary science approves. It is quite unreasonable to expect the older men to be experts in this direction. The training which engineers now in responsible charge of work received at college was too much filled with other things to leave room for that training in chemistry, physiology, bacteriology, vital statistics and epidemiology, which together are called sanitary science. The tendency is and has been to leave a knowledge of this subject to persons who have had unusual opportunities to become experts.

Important also in restricting the capacity of engineers as sanitary experts is the fact that they are too often required to be executiv officers rather than the creativ heads of the work with which they are connected. Their undertakings are likely to be cut out for them by persons who are competent enough, perhaps, to attain prominence in politics or business affairs, yet know nothing whatever of engineering. Apparently every person who has any opinion at all, or sees the desirability of having any, is capable of gathering a following by advocating some alleged sanitary measure. Nowhere are bold assertion and charlatanism capable of going farther than in the kindred arts of curing and preventing diseases.

These facts are illustrated in the experience of nearly every

large city and account in no small measure for defectiv systems, inadequate water supplies and plants for the disposal of sewage and garbage which are commercial successes but sanitary failures. But since the public looks to engineers to stand between them and unwise schemes of sanitary improvement, it is our duty, as far as practicable, to merit this confidence. This means that we should all take a greater interest in the relation of sanitary science to municipal engineering and seek to make our knowledge of the causation of disease more definit, precise and practical.

DISCUSSION.

MR. MAX L. BLUM.—There is one little problem I would like to have the author tell about, and that is the problem of ventilation of the subway.

MR. GEORGE S. RICE.—I think Mr. Soper will have to refer you to reports of this commission or the files of this Society. That matter has been gone into very thoroly. He made a very complete report and the whole matter will be publisht inside of two weeks. Perhaps, however, Mr. Soper would like to say something about it at the present time.

DR. GEO. S. SOPER.—I should like very much, on some other occasion, to say a good many things that would be of considerable interest in connection with the subway matter. I am pleased to hear from Mr. Rice that something will be publisht soon with respect to the subway ventilation.

MR. GEORGE S. RICE.—I would like to state that the Board has just finisht the report relating to the dust in the subway and how the men at work in subway have been affected; it is a very complete report.

The report which Mr. Blum asked about, to which I referred, was a report which was made about a year ago, but happened to be after the time of the publication of the last report of our Commission. The whole subject has been gone into, and a complete analysis made of the whole question, by Dr. Soper's report in the Rapid Transit Commission's records.

We are very much indebted to the author for his very interesting paper and I know that in thanking him, which I now do, I offer him the thanks of the Society.

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK

Paper No. 34.

PRESENTED SEPTEMBER 25, 1907.

TRAVERSE WORK IN CONNECTION WITH THE TRIANGULATION OF THE BORO OF THE BRONX.

BY MR. EDWARD H. HOLDEN,* MEMBER OF THE SOCIETY.

WITH DISCUSSION BY
GEORGE S. RICE, HERMAN K. ENDEMANN, GEORGE W. TUTTLE, WM. F. JOHNES, NOAH CUMMINGS, WILLIAM L. SAVACOOL, GEORGE A. TABER, EDWARD M. LAW, HENRY W. VOGEL, AND THE AUTHOR.

I dout very much if the work of the Topographical Bureau is either correctly understood or appreciated. By that I mean that the work, by reason of its very nature, is such that, upon its successful completion, with all the topographical features well defined and a system of streets with its lines and grades in conformity with them, as far as a good lay-out or plan will allow, there is little or nothing to show for the labor, time and money involved.

In other departments, we have a graceful bridge of faultless lines, a well appointed sewer reclaiming low lands, and furnishing sanitary homes, a grand boulevard with fine roads, paths and walks, imposing bildings, the crowning success of architectural design, etc., yet the backbone of them all, and of all city improvements, must be the silent stones at the street corners.

The essentials of a Topographical Bureau are as follows:

A topographical map on a scale embracing the entire district, showing contours, rivers, roads, etc.

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*Assistant Engineer in charge of Surveys and Monumenting, Topographical Bureau, Boro of The Bronx.

Section sheets of the same on larger scale showing more detail.

Traverse sheets with range lines showing the traverse lines and stations with full dimensions.

General map of the entire section showing plan of streets.

Sectional maps of the same on a larger scale, showing contours, street lines, monumented lines, with dimensions and grade elevations.

An accurate and complete record.

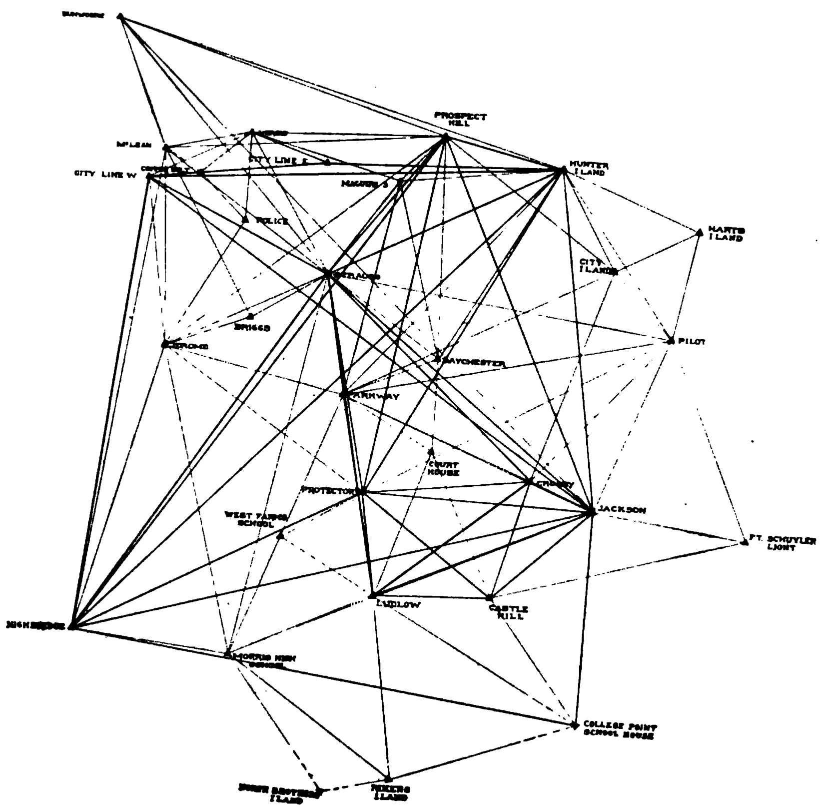
I shall this evening speak of the traverse work. All physical features of the earth's surface, together with the improvements man has made, are located or defined in space by their three dimensions. Two dimensions are generally given by latitude and longitude, or by rectangular co-ordinates; the third dimension by its elevation above some datum plane, generally sea level.

The co-ordinates of a point are obtained indirectly by means of traversing. A traverse is a series of lines whose lengths and directions in relation to one another are known. By referring all traverse lines to a single direction thru an initial point, called the origin, we have the regular system of rectangular co-ordinates. Some means of control over the traverse work must exist if the work is to be the basis for monumenting a street lay-out.

To-day a system of triangulation is generally adopted as that control. Formerly, where no such control was maintained, the procedure was thus: a first traverse was run and balanced in the usual way, on itself; a second traverse was run and balanced on part of the first; a third on the second, and so on, each succeeding traverse being bilt upon the preceding ones.

Whether you embrace the whole territory by a large traverse and cut it up in smaller areas, or bild up the whole by the smaller ones, the fact remains, that if you take a point at an appreciable distance from the origin, the necessary balancing makes one doutful of the accuracy of its co-ordinated position. One of the greatest sources of error in balancing is that the principle of it assumes that the error is uniform, whereas, in practice, local errors frequently occur, and, unless they are large, there is no way of detecting and locating them. Consequently your good work is vitiated by some local error, as for example, a miscall in the tenths of a foot, or the chainman, in reading the tape upside down, counts his hundredths from the wrong tenth.

PLATE 41.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOLDEN ON TRAVERSE WORK
OF BRONX BORO.



TRIANGULATION SYSTEM OF BRONX BORO.

An error of this kind cannot be balanced or distributed over the entire work, but remains a local error, and at each traverse station either way this is felt, becoming proportionately as the length of the traverse increases.

The result is that when you have your district traversed and the positions co-ordinated, these co-ordinates are misleading and do not give the true relation between the positions, and when you project a straight line thru two, three or more of your adjoining traverses, you find in the field that your intended straight line has as many bends as the number of traverses it involves.

The same thing is true for the angles of intended streets and avenues, and your instructions for laying them out will not develop the map or required angles.

It is to this end that the principle of control is brought to our aid, and by it we have our traverse runs under control to the extent of the precision of the triangulation.

In order to keep up the standard of precision in the field work one must keep an everlasting vigil on the work itself. Whenever a monument or point is used as a basis of new work it is most important to verify the correctness of its position. This may seem self-evident, but I can assure you that the neglect of this matter has resulted in more ruination of good work, more perplexity and gray hairs, than all the other combined causes. When the work is new all may go well, but when you deal with monuments set years ago, when instruments and methods were not up to the present standard of precision, you will find inconsistencies, which, if not eliminated, will certainly cause serious trouble. You will be compelled to deal with property maps, made by surveyors, which show street lines and block dimensions differing materially from the same quantities when measured on the ground. For example, suppose that in making the map of your street system it is desirable to keep the lines of a street shown on a certain field map, and suppose that the monuments as shown on the map, when tested by traverse, fail to give the required angles and distances, the problem for you is which shall be held? The street on the ground or that on the map? If you attempt to keep both your mistake will prove fatal. In such cases insist on a change in the map to agree with the monuments in the ground or vice versa.

The Charter of Greater New York calls for a triangulation in conformity with the methods of the United States Coast and Geodetic Survey, on which all maps are to be based.

This triangulation was begun in May, 1903, under the direction of Mr. A. T. Mosman of the United States Coast and Geodetic Survey.

In July, 1904, the President of the Boro of The Bronx began the erection of signal stations in his boro and it was my privilege to be assigned to the work. A reconnaisance survey was made showing the inter-visibility of the proposed stations. A plan of the same was submitted to Mr. Mosman from which he laid out the base net and general triangulation scheme. The base line selected was situated at Unionport and so named, its length being approximately 12 000 ft.

Sixteen triangulation towers ranging from 30 to 84 ft. in hight were bilt, which, together with eleven bildings and two poles, constituted the 29 stations of the Boro of The Bronx.

In the construction of these stations high poles were used which materially expedited the work. These were set vertically at the proposed station and, by climbing the pole until you can see all the surrounding stations, you get, in one operation, the required hight of the tower.

Without its use, one must occupy every station to determine the inter-visibility of that station and the proposed one.

High poles are made of spruce and are 6 in. by 6 in. by 100 ft., consisting of 3 in. by 6 in. by 20 ft. bolted together, and breaking joints every 10 ft. The pieces are laid out on the ground in exactly the position they occupy when in the air, and markt piece for piece. The holes are bored for the bolts, the bolts put in place, and then removed. Cleats are nailed on one side of the pole, 1 ft. apart, by which the observer climbs.

The first or lowest section of the pole consists of two widths of 3 in. by 6 in. bolted together, making 6 in. by 6 in. for a hight of 20 ft., and a half member extending 10 ft. higher, the upper piece breaking joints with its opposite half. The first or lowest section is laid on the ground with its foot lashed to a stake, raised by ropes and pulleys, and steadied by guy wires. Attacht to the top is a pulley block by which the next member is hoisted by ropes,

PLATE 42.
THE MUNICIPAL ENGINEERS
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HOLDEN ON TRAVERSE WORK
OF BRONX BORO.

TRIANGULATION TOWER.

bolted in place and properly guyed. This operation is repeated until the entire pole is raised. The pole can be laid out and raised in one-half a day, the horse and truck used in hauling the lumber can also be used as power for raising. Five men constitute the necessary force.

The field work under the direction of Mr. Mosman was begun October 22, 1904, and finisht in the fall of 1905. The official report of the final results of the survey was received from Washington in December, 1905. It embodied the geographical positions of all the stations, the azimuths and back azimuths of the lines, and the rectangular co-ordinates of the stations. Upon receipt of the report, the Topographical Bureau began the work of connecting the traverses with the stations and, in many cases, running new traverses connected directly with them. The Bronx official standard of length has been that of the Department of Public Parks. A comparison of this standard and that of the U. S. Coast and Geodetic Survey showed a difference of 0.01 ft. in 100 ft., so that in adjusting the traverses to the new survey, the lengths were first corrected for that difference, then started and closed on triangulation lines. The directions of many of the old fixtures, laid down and monumented, differed from the results of the coast survey. Where title had vested in streets and avenues, as well as where procedings had been instituted, the physical lines had to be kept, and the directions and lengths as fixt by the triangulation simply played havoc with the final maps.

Imagine an error in direction of a certain line amounting to from 0 to 20 sec., and the line as monumented to be kept, also a lay-out of streets at right angles to it, the fixtures at the other end of the streets being at right angles to another line where no error exists, and you will agree with me when I congratulate the other boros and tell them, they do not know what they have missed.

In general, traverses connecting the triangulation stations are called primary traverses. They are made with utmost care, every precaution being taken to exclude errors, the chaining being done in duplicate, and the two results should not differ by more than .02 per 1 000 ft. The work should be done on cloudy days whenever possible.

In primary traverse work, the tape is not used level, but on

slopes which are measured, a constant tension is maintained by the use of mechanical stretchers, the temperature is determined by thermometers attacht to the tape itself, and the tape held by stakes or portable tripods.

The tapes are standardized exactly in the way they are used in the field, *i. e.,* supported in the same way and with the same tension. Thus no correction is necessary for sag or tension.

For secondary traverses, the regular city engineer's 50-ft. spring balance tapes are used with plumb bobs and tacks in the ground for marking pins.

Tape Stretchers.

The front tape stretcher consists of an upright, hinging sideways at its lower end on a foot base, and terminating at the top in a handle. On this upright, traveling up and down, is a block carrying the spring balance to regulate the tension. The tension is applied by a revolving half wheel centered in the block and operated by a lever attacht to its diameter. By means of the vertical motion of the block, the balance and front end of the tape is raised or lowered, while the hinged motion of the upright gives lateral adjustment necessary for alignment. The rear stretcher is similar to that in front with the exception of the spring balance.

The advantages claimed for this stretcher are: that it is manipulated with ease; that it is instrumental in producing more accurate work, because the tension can be maintained more easily and for a longer time than can be secured from other forms. The tension is absolutely under control for almost any length of time. With the tension releast, the stretcher is self-supporting, allowing one quickly to protect the tape from inadvertent injury.

In the winter of 1905, in standardizing a number of steel tapes 100 ft. and 150 ft. long, we utilized the basement of the Eighth Regiment Armory. The tape stretchers were used in this work and they enabled us to observe and note differences of 0.0001 ft. There were something like a dozen tapes tested and the work consumed about one week. This 0.0001 ft. may strike some as an impossibility, but this small difference was observed constantly for a whole week.

These tape stretchers are invaluable in standardizing and testing tapes; in fact, they are indispensable.

PLATE 43.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOLDEN ON TRAVERSE WORK
OF BRONX BORO.

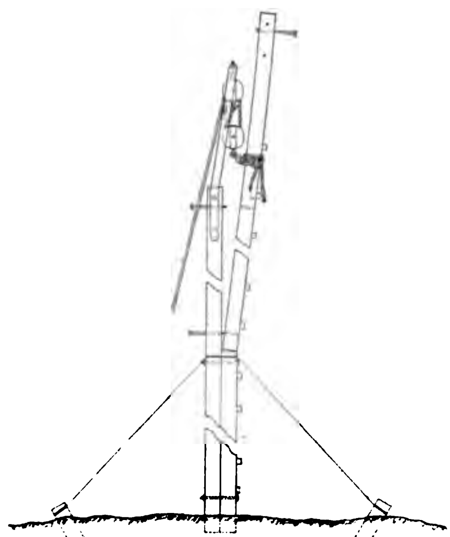

FIG. 1.—DETAIL OF TEMPORARY HIGH POLE.

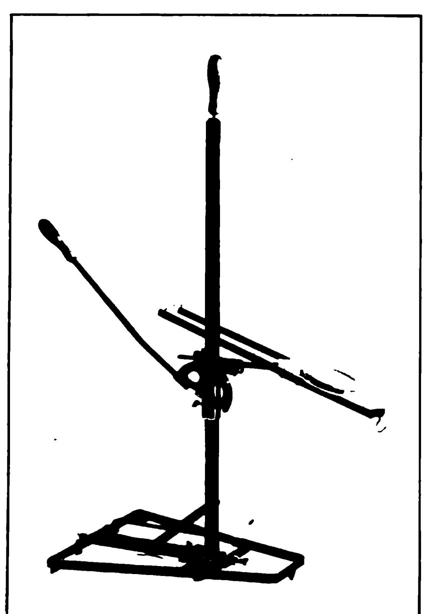

FIG. 2.—FRONT TAPE STRETCHER.

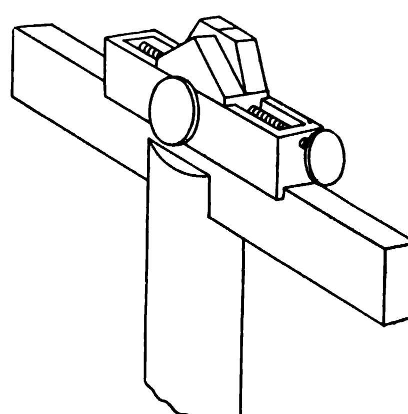

FIG. 3.—DETAIL OF TOP OF TRIPOD.

PORTABLE TRIPODS.

The portable supports are of iron with a round bar adjustable in hight. The top of the bar terminates in a rectangular cross-piece forming a "T" shape with the bar. This cross-piece forms the track on which slides a block which forms a support for the tape, and adjacent to it, at a level with the tape, is the index mark which, by means of a tangent screw, is brought to coincide with the tape graduations. The block is set approximately near the tape graduation by sliding it along the bar and then clamping it. With the use of these tripods the driving of the projecting stakes is avoided, likewise effecting economy in time. You can measure lines that do not permit of driving stakes, *e. g.*, parks, lawns, pavements, etc. It is usually necessary to have the stakes or supports for tapes from 18 in. to 36 in. above the surface of the ground. In many cases this is impossible on account of the danger to travel as well as the annoyance of replacing if disturbed. They should have a cross-section of 4 in. by 4 in. to insure stability and should be well driven in the ground, which means that the staking out takes considerable time. These conditions together with the impossibility of using them on pavements, rock formations, etc., give the portable tripods a decided advantage.

As to the use of plumb bobs you will get diverse expressions of opinion, but all will, I think, admit that plumb bobs have a proper place in the engineer's outfit. A mechanical test of a bob in a lathe does not prove homogeneity of metal, nor does it make a bob strung carelessly, give accurate results. A large hole for the string and a knot forming a shoulder on one side will destroy the accuracy of the best bob. The test of a bob is that the line passing thru the center of the cord suspending it shall, when produced thru the bob, pass thru the point. Airholes in the casting render a plumb bob worthless and still the lathe test passes it as perfect. The boring of the top to receive the string, if not eccentric, results in an imperfection. The hanging of the bob in the string, if not made concentric, is equally faulty. Every plumb bob used by the Topographical Bureau is tested, and rejected if not found correct. Every time a tape or chain is tested, the plumb bobs used with it in the field are first tested.

Equal care is taken with the measurement of angles, at least

two sets of six repetitions each being taken, and closing the horizon so that the closing reading shall be within at least 10 sec. of 360 degrees. These limits have been easily maintained under normal conditions and reduce the traverse error to ½ in. per mile, which is the minimum distance between the triangulation stations.

As an example, the distance between Parkway and Baychester was measured with our primary apparatus, the distance being 6 347.356 ft. Two measurements were made, differing by .01 ft. This measurement referred to triangulation station 6 204.25 *vs.* 6 204.37 U. S., a difference of 1 in 51 000.

The line was divided into five sections and was defined by monuments set before the measurements were made. The first section was measured three times, its length being 3 149.8185 ft. The greatest range being .0044 ft., or a probable error of 1 in 4 500 000. A test record was kept of the time taken for the measurement, 2 400 ft. taking 45 min., a rate of 100 ft. in 2 min.

On Tremont Avenue, from Eastern Boulevard to Fort Schuyler Road, 8 000 ft. (over the line and back again) were measured in 5 hr. and 55 min., a rate of 100 ft. in 4½ min. Many obstacles presented themselves, much clearing being necessary. The line crost the salt meadows and, the tide being up, the men had to pick their way over and around the streams. It was one of the worst places in The Bronx for this kind of work. The work being essential, was done with the primary apparatus and the results are given just as it was accomplisht.

The line over the Eastchester Meadows was divided nearly equally by a large rock or boulder known as "Cactus Knoll." Each section was measured four times; the sections, as measured, are as follows:

EASTCHESTER LINE.

Cactus Knoll—Maguire.

1	6 688.5988 ft.	— 0.020
2	6 688.6035 ft.	— 0.015
3	6 688.6388 ft.	+ 0.020
4	6 688.6341 ft.	+ 0.015
Average	6 688.6188 ft.	

Cactus Knoll—Paul.

1...............	5 322.8185 ft.	+ 0.0110
2...............	5 322.8558 ft.	+ 0.0483
3...............	5 322.8056 ft.	— 0.0019
4...............	5 322.7501 ft.	— 0.0574
Average.........	5 322.8075 ft.	

making a total of 11 190.08 ft. as against 11 190.32 ft. as given by the triangulation, or a difference of one part in 46 600.

The monumented line of White Plains Road runs approximately parallel with this line over the Eastchester Meadows, being about 10 000 ft. distant. Cross-tie traverse lines connecting these two lines were run thru Two Hundred and Thirty-third Street and Gun Hill Road or Two Hundred and Tenth Street, the distance between the last mentioned streets being about 6 000 ft. The error of closure was 0.012 per 1 000 ft. and the six angles gave an angular error of $\frac{7}{10}$ sec. per angle. The total length of the traverse was 32 000 ft.

The line of Eastchester Meadows was measured with a 300-ft. tape (its cross-section being $\frac{3}{32}$ in. by $\frac{1}{50}$ in.), known as hoop skirt wire. The tape was supported every 50 ft., and the tension was 16 lb.

The standardizing of this tape afforded an opportunity for studying the effects of temperature and forms of thermometers necessary with the different cross-sections of tapes.

A field comparator was establisht at the northeast corner of the ball ground at Crotona Park, and its length was determined by the applications six times of the Park Department 50-ft. standard length. This was done before sunrise to avoid the effects of the sun. The greatest range in these measurements was 0.003 ft. The 300 ft. was measured twice in the morning and three times after sundown. It was again measured at an interval of two weeks and found, by two measurements, to be correct. The thermometers used were the chemical thermometers, having no backing or support. They were graduated to single degrees, and estimated to ¼ degrees. Tests were continued from sunrise on, and soon it was certain that

no reliable results could be obtained when the sun was shining. Another fact made itself manifest, which was that any kind of a thermometer would not answer for all tapes, and that certain thermometers would not answer at all. For instance, the thermometer of the so-called city engineer's tape is housed in a tube of brass which stores heat and renders the thermometer readings misleading. Any excess of metal or anything else which stores heat more than the tape does is bad. The comparator was advantageously located in a place that was shaded from the sun in the morning, and the proximity to the park caused alternately cool and warm currents of air about the tape. Thus it was impossible to note the tape lengths and the corresponding thermometer readings. The tape was first watcht, and, at a noted change, the thermometer readings were simultaneously recorded. This was repeated several times and then the operation was reversed, *i. e.,* the thermometers were watcht and the tape lengths recorded for the change noted in the thermometers. With the chemical thermometers, the corresponding changes tallied remarkably well, but with others this was not the case, and their use was discontinued. The cross-section of the tape regulates the sensitivness required in the thermometers.

An interesting fact has been observed in the 300-ft tape, which was that it was constantly increasing in length. The cause, we think, was its small cross-section for the 16 lb. tension. Greatest care had been taken in reeling and unreeling, so that its change in length could not have been due to that. The fact remains that it stretcht, and Mr. Mosman, in his criticism, called attention to the possibility of change in length of the city chain. A low tension does not receive the endorsement of the U. S. Coast and Geodetic Survey. Our experience justifies the abandonment of small cross-sections and low tensions.

About a year ago some steel tapes were received from Keuffel & Esser, the cross-section was $\frac{1}{4}$ in. by $\frac{1}{50}$ in., and the outer surface was tinned to avoid rusting. It was found that they did not respond to temperature changes the same as the steel tapes of the same cross-section. The explanation is that the surface, being bright, reflects some of the heat and does not, therefore, expand the same as the dull steel tape.

Invar Tapes.

During the summer of 1906, four nickel steel tapes (Invar) were used with most satisfactory results by the U. S. Coast and Geodetic Survey on the measurement of six bases having an aggregate length of 60 km. From information given by the Coast Survey, I quote as follows:

"The coefficient of these tapes, as given by tests made at the National Bureau of Standards, ranges from 0.0000002 (two ten millionths) to 0.00000025 (two and one-half ten millionths) per degree Fahrenheit. The yield point is about 70% of the tensile strength. The tensile strength is 100 000 lb. per sq. in. Steel tapes of the same dimensions show 197 000 lb. per sq. in. Previous tests made on similar tapes in England have shown that the minimum safe diameter of reels on which these tapes are to be wound is 16 in. If a reel of smaller diameter is used a permanent change in the length may be produced by the reeling and unreeling. This low coefficient means that the expansion of the Invar tape for one hundred (100) degrees Fahrenheit for 1 000 ft. would be 0.02 ft. Allowing an extreme error in temperature of 10 degrees, the temperature error for a mile would be 0.01 ft. These tapes are $\frac{1}{4}$ in. by $\frac{1}{80}$ in. and 50 meters between graduation. When in use, each tape is supported at the ends and at the middle and is under a tension of 15 kg. (about 33 lb.) applied by a spring balance."

Mr. O. B. French in an article publisht in the *Science,* states:

"The tapes were tested for considerable range of temperature, reeled and unreeled a large number of times, and also tested for the continued application and removal of light loads, without showing any change in length. The coefficient of expansion is $\frac{1}{28}$ that of steel."

In the measurements of the bases referred to, three steel tapes were used at night, while the Invar tapes were used in daylight. Mr. French also states that the steel and Invar measures were computed independently. The differences between them are small, the largest being one in 300 000 and the average one in 500 000. The probable errors of the bases from the steel measured are more than double those from the Invar measures. The final probable errors of the bases, giving the Invar double weight, are between one in 2 500 000 and one in 5 000 000.

In 1900, the U. S. Coast and Geodetic Survey demonstrated that steel tapes gave the same accuracy as the bar apparatus with one-third of the cost. It is now shown that Invar tapes give results considerably more accurate and economical than steel tapes.

With mechanical stretchers for the front and rear of the tape, and portable tripods with adjustable heads to quickly and accurately hold the tape lengths, the error due to manipulation is reduced to nothing, and with the Invar tape, measurements can be made with no appreciable error.

Unfortunately, the Invar tapes ordered in December, 1906, for The Bronx have not been delivered, some mistake having been made in the manufacture, but the tape stretchers, portable supports, etc., are here for your inspection.

Spring Balances.

The spring balance used with the city engineer's tape is faulty in respects other than that of the thermometer. It has, to my mind, a wrong construction. The level tube is at the handle end, *i. e.,* that further away from the tape and slides inside the thermometer tube. The thermometer tube being attacht to the tape, takes a certain inclined position due to the catenary of the tape. This inclination must be secured every time the tape is used. For this position you rely on an inner tube which cannot be fitted close enough to insure parallelism without affecting the tension. The slightest movement out of parallelism affects the level and, therefore, the front and rear end of the tape. To my mind, the proper construction would be a reversion of the parts, *i. e.,* have the inner tube carrying the level immediately next to the tape, with plenty of play between the inner and outer tubes. The level tube being absolutely free from friction, would insure accuracy both of the level and tension.

A further suggestion would be to have the end graduations on the tape, and thus do away with the wear of the links between the tape and graduation on the handle.

The spring balance tapes, 50 ft. long, are inspected in a general way for tension, compensation scale, etc., when they come from the makers. Before they are taken in the field, they are tested for

length. They are tested from time to time, at least every two months, to be sure they maintain their correctness. In the basement of the Municipal Bilding, The Bronx standard length is defined by fine cuts in copper bolts of 1 in. diameter, set 12 in. deep in the granite cube. These are set in concrete forms 4 ft. square and from 3 ft. to 4 ft. deep, resting directly on solid bed rock. The mechanical stretchers are supported by sidewalls of the basement. A clutch, taking the place of the hand, receives the tape handles and is adjusted by mechanical means for elevation, side motion and tension. Once set, the tape can be kept rigid in that position for a month, if necessary.

Reference points for the long tapes are of similar construction. They are set in the ground at the northeast corner of the ball ground in the northerly corner of Crotona Park. The extreme distance between the monuments is 300 ft. with an intermediate one at 150 ft. The definition of the centers of the monuments are carried up by means of the vertical collimators. Being outdoors, the objection to it, is the uncertainty of temperature.

There is now under construction, in the new bildings of the Department Yard at Webster Avenue and One Hundred and Eighty-first Street, a comparating room, 160 ft. long, for testing and standardizing tapes. Here the temperature will be regulated by a heating apparatus and thus provide for the determination of the coefficient of expansion as well as lengths at any desired temperatures.

I have endeavored to tell you what The Bronx has done and is doing toward a higher standard of topographical surveying. Anything I may say about topography would not be complete without bringing to the front one whose name has been allied to this work ever since there was a topographical bureau. I refer to Mr. Frederick Greiffenberg.

Methods of base line measurements have been revolutionized within the last few years. Today, we have in the "Invar" tapes the greatest advance toward perfection in lineal measurements, far beyond the dreams of the most sanguin enthusiast.

DISCUSSION.

MR. GEORGE S. RICE.—Gentlemen, you have heard what they are doing in The Bronx. There are other boros in the City of New York and I know other work has been going on there. Mr. Endemann, from Queens, I think may have something to say.

MR. HERMAN K. ENDEMANN.—Mr. President and gentlemen: We have been following Mr. Holden's lead over in our boro, attempting to do some pretty accurate measuring. I notice that tonight seems to be topographical night in the meeting here. I do not think I ever saw so many topographical men present. The paper has been especially interesting to me and to all of them, I am sure, because it treats of a subject to which we are devoting a great deal of time in Queens Boro today.

There are one or two things I jotted down on paper while Mr. Holden was reading, and I wish to ask for a little information. Was the reconnaissance pole, shown on one of the slides, guyed at intervals all the way up, or only at the top of the first length?

MR. HOLDEN.—They are guyed all the way up.

MR. ENDEMANN.—Three guys, I suppose?

MR. HOLDEN.—Four guys.

MR. ENDEMANN.—It did not show on the picture.

MR. HOLDEN.—I haven't yet reacht that perfection of photography where I can get prints showing those fine wires; we were a little economical on those wires.

MR. ENDEMANN.—I went over to Queens Boro from the Topographical Bureau in The Bronx a number of years ago. In those days the method of measurement in The Bronx had not attained the perfection which it has today, and in consequence we were no further ahead than they were then, and possibly the work was even a little rougher, as we were going into the wilds of Long Iland. We started out with the old 50 ft. spring balance chain, but, altho it served the purpose on a rough topographical survey, after using it for a little while, we became convinced that we required a more accurate method. One of the first things we did was to adopt a longer chain, and the second thing was to attempt to dispense with plumb-bobs, for we appreciated, as Mr. Holden says, that a great many of the errors in chaining are due to faulty bobs. Our method at that time was to set up a transit at right angles to the end of the tape, using an optical square to get the position of the transit. It was set up roughly for position, but the plate leveled carefully, and it did not make much difference provided the tape was held up over the line that was supposed to be measured, if the transit was slightly out of position or not. The instrument was leveled up and the cross-hair was sighted on a graduation markt on the tape, this

mark projected downward, and a tack set in the ground underneath. The tape was then stretcht a second time and the operation repeated, and, as a general rule, we found that the second shot came somewhere on the tack, if not in its center. We would take the average of the two positions for our point.

We used this method for some time and then Mr. Crowell and Mr. Weinberger introduced the method of measurement which, with some modifications, is employed there today. It is somewhat similar to the one Mr. Holden has described. We use a portable tripod on which to get our points, as this can be set up in a hurry. It is a little bit heavy—I should judge it weighs about 40 lb.—and it takes a muscular man to carry one around during the day, especially as the progress in work by this method is quite rapid. Our parties as a rule consist of about six or seven men. Under favorable conditions, if there are not more than say three or four pluses to be taken, we have covered as much as 2 000 ft. per hr.

I think anybody who has attempted accurate measurements and taken all possible precautions to secure the very best results, will agree that the most difficult factor to overcome, is the error due to variation in temperature. As everyone is aware, the temperature of the air is all the time changing, and anyone who has attempted chaining and taken this into consideration, appreciates how much it shows and how often the temperature may vary by a considerable amount. If the Invar tape, of which Mr. Holden has spoken and which we have not tried over in Queens, possesses the advantages claimed by the makers, I think it is going to revolutionize all base measurements. According to the United States Coast and Geodetic Survey and according to Mr. Holden's observations, their claims seem well founded. Of course, in measuring, the temperature proposition is only one of many obstacles.

Mr. Holden mentioned the elongation he noticed in some of his long tapes after using them a while. We have noticed the same thing in our tapes. These are 100 ft. in length and the cross-section is a little different from that of those used by Mr. Holden in The Bronx; ours measure only about $\frac{1}{8}$ in. across and is quite thick. Those mentioned are the tapes which we have recently taken and we find they are a little too heavy. We prefer a lighter tape, about half way between the one we were previously using and this one. Mr. Holden's tape, I believe, is nearer the size of the Eddy tape?

MR. HOLDEN.—The new tapes?

MR. ENDEMANN.—Yes.

MR. HOLDEN.—Yes, about the cross-section of the Eddy tape.

MR. ENDEMANN.—Yours is probably $\frac{1}{4}$ in.?

MR. HOLDEN.—One-quarter by $\frac{1}{50}$ in. in cross-section.

MR. ENDEMANN.—It is much thinner than our tape. One of the things we noticed in our tape, and to which we attribute the elongation I mentioned, is the fact that, in winding on a reel of very small diameter, the outer side of the tape, if the tape is at all thick, is subjected to considerably greater tension than that to which it is subjected in accurate measurements. We feel quite confident that our tapes in taking the measurements are never stretcht to anywhere near the limit of elasticity, and yet we found that this elongation which Mr. Holden has mentioned became greater with the constant use of the tapes and we thought that this could possibly be accounted for in this way. We have experimented some with larger reels for our tapes and we have had a set of reels constructed that, instead of being of the usual diameter, which I think is not more than 12 in., are 18 in. in diameter, and since we have been using these reels we think we have noted an improvement.

MR. HOLDEN.—The tape that we found to stretch was the old "hoop-skirt wire tape" or the old City Engineer's chain, which, as far as I can understand, was devised by Mr. George S. Greene and used in contract work back in the "Seventies." It is the "hoop-skirt wire tape" that stretches, but not the other kind.

A MEMBER.—I would like to ask Mr. Holden if he only measured the temperature on that long tape at one point?

MR. HOLDEN.—A thermometer was placed about 3 ft. from each end and one at the middle—three thermometers in all.

MR. RICE.—There is another boro of New York—Richmond. I think Mr. Tuttle should have something to say on this matter.

MR. GEORGE W. TUTTLE.—Mr. Holden has presented a paper of interest and value. The substantial character of the apparatus, as well as the precautions taken, lead us to expect results of great accuracy. Perhaps the chief source of error in traverse measurements, and the one least under control, arises from the uncertainty in the measurements of the temperature of the tape, particularly when it is exposed to the sun. To avoid this error, the speaker, in 1903, imported some Invar wire, having a temperature coefficient about one-fifteenth that of steel, to ascertain if it was available in ordinary traverse measurements. This wire had previously been used with success in measuring geodetic base lines abroad. The elasticity of the wire, however, was but little superior to that of tin. It bent so easily, and was so difficult to straighten out, that it was useless for the purpose intended, and no satisfactory measurements were made with it.

More recently Invar has been produced in the form of a ribbon, with considerable increase in elasticity, yet it is much below that of spring steel and requires very careful handling.

MR. WILLIAM F. JOHNES.—I would like to ask Mr. Holden about

the three thermometers on the 300-ft. tape. Did you find that the difference in temperature at the three different points was sufficient to warrant their use?

MR. HOLDEN.—Yes, indeed. Further than that, in the measurement of the East Chester base line, where one of our stations happened to be near the water (the front end being at that point and the rear end coming on), we found that one thermometer would sometimes go up and sometimes go down and the other two would give the average temperature of the meadow, and when the rear thermometer came up that went down and the other two went up again, showing absolutely that the thermometers detected the difference in temperature at that spot.

In regard to Mr. Tuttle's remarks about the tape that he got from France, the Invar, I do not think it is fair to confuse that with this tape, because it is an absolutely new construction and the secret of this is what they style an "aging," which takes two months, and it is this "aging" and tempering, after the nickel-steel combination has been formed and the tape is rolled and all prepared, that give the desired results. This "aging" is a secret process. I imagine that it is put in oil and kept at a certain temperature and after this treatment you can reel it and unreel it, as the Coast Survey reports state, and find no change in the length. That has never been said of the tape made by Mr. Guillaume, the French manufacturer of the same Invar. They are two distinct tapes to my mind, the French and the English. I think when Mr. Tuttle sees the English Invar tape, made by Mr. Baugh of London, he will change his mind about reeling and unreeling.

MR. NOAH CUMMINGS.—Mr. Holden did not bring up the question of holding the points after they are establisht. If the points are held by setting monuments level, or nearly so, with the surface of the ground, as is the common practise around New York, then they will shift more or less by the action of frost. Of course the extra refinement in measuring, as explained by Mr. Holden, is very desirable, but whether or not the points are preserved after they are once establisht, is a very important question. I would like to ask if anything has been done in the Boro of The Bronx in regard to this?

MR. HOLDEN.—After the monuments are set to keep them there, is that the idea?

MR. CUMMINGS.—Yes. You measure correctly to within say a hundredth of a foot. You then set your monuments and in a couple of years when you go there again will the points still be within the hundredth of a foot?

MR. HOLDEN.—Probably not, but when you have gone over your entire territory or establisht the total distance on a certain long

line, you know what it was at that time and ought to be at any other time. In former times we never knew what it ought to be. Today we have the satisfaction of knowing the correct length of the line and that the points were originally set correctly. That is more than you can say of the old régime, because just as often as not they were set incorrectly.

The temperature of a steel tape is a peculiar factor. It will follow along in the same ratio as indicated by the thermometer and still sometimes be two or three degrees lower, and at other times two or three degrees higher, and I have never heard of a way of definitly ascertaining the cause. I am trying to insist, up in The Bronx, that we do the work in the best possible manner, irrespectiv of what happens to the monuments afterward. It is bad enough to take those chances, but if you do the original work badly and then take chances of movements afterward, you are getting into deep water.

A MEMBER.—I would like to ask Mr. Holden what method is used in The Bronx for measuring short distances in base line work?

MR. HOLDEN.—Mr. Cook, I think, is here and he can answer that better than I, because, while I was on that base line, I consider that that is the province of the Coast Survey. I simply treated traverse work in connection with that, and the small distances forward or backward from the regular stationing were measured with the Chesterman tape.

SAME MEMBER.—When I said base line work, I referred really to traverse work. I did not mean Government work.

MR. HOLDEN.—We measured with the Chesterman steel tape.

SAME MEMBER.—Does that not begin to introduce quite a large error?

MR. HOLDEN.—No, we avoid continuing measurements from an intermediate, but try to proceed by tape lengths continuously. If we take pluses, it is simply a plus from a certain station, and the aggregate of each length appears in the aggregate length of line.

SAME MEMBER.—The only place where an error would occur would probably be at the very final point, the break in the line?

MR. HOLDEN.—Yes.

SAME MEMBER.—Another thing struck me as rather strange was in your picture of the best instrument, I noticed that it was a 4-screw instrument. I have always understood the best practice for the most accurate work was a 3-screw instrument.

MR. HOLDEN.—The instrument that I referred to as the best instrument in The Bronx was a 3-screw instrument and it was set on a triangular tripod.

MR. WILLIAM L. SAVACOOL.—I have been on topographical work under Mr. Endemann for about two years and a half, and during

eighteen months of that time I have been in charge of a primary traverse party. Part of the time we were measuring with the spring balance 100-ft. catenary chain, and for a year using the chaining tripods with a 100-ft. chain. From experience with catenary chains I noticed that these chains were constantly elongating, which verified Mr. Holden's experience, but I was surprized to hear Mr. Holden say that a chain should be standardized about once in two months. Now, I would say once a week. In a week we usually measured about 25 000 ft. with the catenary, and in looking back over that time, I believe that we did not compare our chain with the standard as frequently as we should have done. Later we came to realize more and more the importance of having a standard with us in the field for a reference at the end of each week's work, or at the completion of one piece of work before beginning a new piece of traverse measuring. A chain will oftentimes pick up an error of two thousandths in a week, due to some kink that you would not think would affect it very much. Then, again, you will find it is about the right length. It is very hard to tell, within a thousandth, just what the true length is. At the present time, in our practise, each field party carries a standard chain with it and is supposed to make a comparison at very short intervals. We have three main standards, which are kept in secure places. They have been to Washington and are known to be of the exact 100 ft. length. The standard which each chief of a field party has, has also been to Washington, and, after coming back from there, has been recompared with these three main standards by ourselves, so that we also know that these secondary standards are absolutely right, and from time to time they are again compared with a main standard, to discover any variation in length due to injury or service. In that way we keep a very strong check upon the uniformity of the standards used by the several field parties.

We use 100 ft. chains entirely and I imagine that a 300-ft. chain would be very awkward at times. In measuring primary traverses in Queens, we often have to chain diagonally across busy streets, and we sometimes have to stop the cars for three or four minutes while we complete a measurement. If we used a 300-ft. tape, such as Mr. Holden uses, the difficulties caused by traffic would be too great to handle with the ordinary number of men in a field party.

Another thing that unfavorably imprest me was the very complicated apparatus used at the head of the chain for keeping the pull uniform. The simple method which we use is to have a pole, with a sharpened spike at the lower end, which we push in the ground when we can, or if chaining on pavements we put it between the paving blocks for a grip. This pole is placed under the

arm when a man applies the pull and he bends forward at the same time and looks down on the spring balance. He can therefore see what pull he has, and my observation is that the pull does not vary appreciably after the rear chainman says "right." The man who marks the distance on the forward table does not make the mark until he hears both the man at the rear and the man at the balance saying "right." Our apparatus at the rear is very simple. We use only one man at the rear and he has a cross arrangement so that he takes the pull on his body and no pull is taken on the chaining table, and he, too, becomes very skilful. It takes two or three days to break in a man for that position, but after that time he becomes skilful and holds absolutely steady at the rear chain, calling "right" at all times when he is right.

We require our measurements to agree within $\frac{15}{1000}$ ft. in 1 000 ft., always measuring each line at least twice, and we find that we are able to attain this accuracy with considerable ease, altho, of course, accidents do happen. When results do not check, we remeasure the line, but in many cases—in fact in the majority of cases—we have an agreement much closer than $\frac{15}{1000}$ ft. in 1 000 ft.

Our chaining tables have adjustable legs somewhat similar to those of a mountain transit, and can be readily adjusted to any hight. In chaining thru swamps, the legs can be driven deep into the marsh to secure a solid footing.

In conclusion I would say, that in Queens we attain the needed accuracy with an apparatus less complicated than that shown here by Mr. Holden, and the apparatus is such that it is adapted for use under all conditions of traffic and topography.

Mr. George A. Taber.—I would like to ask if the Topographical Bureau has ever made use of the principle of determining the temperature of the tape by passing a current of electricity thru it and noticing the electrical resistance?

Mr. Holden.—If my memory serves me right, the Coast Survey have tested, or tried that method, and they say that perhaps it will be put in form so that it can be used.

The University of Michigan, I think, started that idea and I believe has had very good results, and theoretically it is "a good method." Why it has never been put into actual practise I could not say, but it is a good thing if it can be managed and if it is practicable.

Mr. Taber.—That is just the question I wisht to have answered—whether it was practical or not. I know such experiments have been made.

Mr. Holden.—I never had any experience with it.

A Member.—In reference to the electrical measurement of resistances, I have gone a little further—in thought only—that is, to

measure distance by electrical resistance, which can be done, but it cannot be done accurately for one reason and that is, it is almost impossible to get a naturally uniform wire or band, as far as cross-section is concerned, all the way thru, and it is upon this cross-section that the resistance of the tape depends. If the resistance of error is all the way thru the different parts of the tape, the distance is not going to be accurately recorded. I think that is the great difficulty. If it were possible to get a wire or tape of an absolutely uniform cross-section and an absolutely steady current, not only could temperature be measured with the electric method, but distance itself could be measured accurately, but lack of that possibility makes it theoretically very nice, but practically not very useful.

A MEMBER.—I would like to ask, Mr. President, how much current they would use in determining the temperature of a tape by measuring its electrical resistance?

MR. TABER.—That is a detail which I do not recollect. The experiments to which I have already referred were made by the Massachusetts Institute of Technology at its "Summer School" held during the summer of 1893 in the northern part of the Adirondack Mountains. A complete system of triangulation was establisht between the surrounding mountains, and a base line about a mile in length was measured in the valley, after which the topography of that section was mapped by means of plane tables.

I had the good fortune to assist in this base line measurement, in which the temperature of the tape was determined by measuring its electrical resistance. The current, as I recollect, was produced by a small field battery, and I think it was not very powerful. The measurement of the base line was repeated several times with very close agreements. The U. S. Coast and Geodetic Survey took up this matter with the Institute of Technology and the accuracy of the results was workt up with their assistance. I understood that this method gave very satisfactory results. I have never heard, however, of its being further employed in practical use, and it was with the hope of obtaining information on this point that my question was asked.

A MEMBER.—I would like Mr. Holden to tell me how the measurements are made on steep slopes, where it becomes necessary to use a chain shorter than 50 ft. I understand the catenary chain is only graduated at the ends and has no intermediate graduation.

MR. HOLDEN.—The limit of slope is 10%, where these tapes can be used, and if you have anything over that you must either resort to the spring balance or anything else that you choose. You can triangulate the distance from two points nearer level; that would be one way.

A MEMBER.—In your chaining in The Bronx, do you always attempt to have the tripods on the same level?

MR. HOLDEN.—Not at all.

SAME MEMBER.—Your chains are always level, I understand?

MR. HOLDEN.—No, sir.

SAME MEMBER.—That was a City Engineer's tape?

MR. HOLDEN.—That is used for the secondary work. I thought I explained that fully, but evidently I did not.

Our primary work and our primary traverses are based on the primary apparatus, which is the long tape and the mechanical stretchers and all the refinements that we can put on to insure accuracy, no plumb-bobs whatever being used. With the secondary work, we use the Engineer's City chain, or so-called City Tape, which is 50 ft. long, and the hoop-skirt wire, which is very light, and has the spring balance attachment. This tape must, of course, always be used level. There are many places around Riverdale where there are steep slopes and you have to work with 10 ft. lengths, if you want to measure it; the best way is to triangulate it. Many of the slopes in Riverdale, down to the river and the railroad track, will not permit of any greater distance being measured on the level than 10 ft.

MR. EDWARD M. LAW.—Mr. Holden has referred to the co-ordinate system used in the triangulation of The Bronx. In the different boros of our Greater City different meridians are used, and I think a committee ought to be appointed to investigate this. The 74th meridian is the one that should be generally adopted for the whole city. It is already used by the Dock Department and has been used by the Boro of Richmond. It is centrally located and therefore can be referred to by all the boros.

MR. HOLDEN.—The greatest objection to that is that you cannot use the rectangular co-ordinates and it complicates the matter materially, and, in the opinion of the Coast Survey, each boro was to have a meridian line laid out centrally in that boro and then have your rectangular co-ordinates. If you go to a larger scale than that, you must use spherical co-ordinates.

MR. LAW.—Not necessarily. The divergence is so very small that it does not enter into account.

MR. HOLDEN.—You mean a Central Meridian could be instituted over the five boros?

MR. LAW.—Yes.

MR. HOLDEN.—Well, the Coast Survey differ with you and it seems to be a difference of opinion. Spherical co-ordinates are not practical for surveys of any large city.

MR. HENRY W. VOGEL.—I would like to ask the gentleman if he has calculated the difference. The convergence of meridians in

a distance of 20 miles amounts to 1 ft. and 4 in. Greater New York can be included in a square having a length of 40 miles on each side. For this reason 20 miles is taken as the extreme distance of any side from a central origin.

MR. LAW.—Well, I would like to see the figures.

MR. VOGEL.—I had the privilege, about 27 or 30 years ago, of running out the northern boundary of the City of New York and determining its geographical position, and you will find that in the great circles of the earth which coincided with the northern boundary of the City of New York, as it existed then, from the Hudson to The Bronx River (we had not then annext the territory east of the Bronx River), there is a very appreciable difference between azimuth and back-azimuth.

MR. LAW.—The azimuth and back-azimuth is a comparativly insignificant question on accurate traverse work.

MR. VOGEL.—It is not an entirely different question, because azimuth and back-azimuth show a convergence of meridians at either end of a line; that is all that azimuth and back-azimuth signify.

MR. LAW.—It is not affected materially by the convergence of meridians in the four quarters.

MR. VOGEL.—It certainly is. It is not increast geometrically. I would like to ask Mr. Holden one question. He spoke of a spring balance chain in which he suggested an improvement by placing the measuring mark not at the spring balance near the level, but up on the hoop-skirt wire itself. Has he ever tried the tape in that shape? Does it not make the distance between the tension mark and the graduation mark too great for the eye to watch?

MR. HOLDEN.—No, sir. In the new construction, the tension mark, level and graduation mark are at the rear end of the attachment and within easy range of the eye.

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THE DESIRABILITY OF CENTRALIZED ENGINEERING CONTROL FOR NEW YORK CITY.

BY MR. M. N. BAKER.*

WITH DISCUSSION BY
GEORGE S. RICE, MAX L. BLUM, RUDOLPH P. MILLER, EDWIN H. THOMES, ARTHUR S. TUTTLE, ALBERTO SCHREINER, ROBERT R. CROWELL, WILLIAM R. HILLYER, HENRY W. VOGEL, JOHN T. FETHERSTON, DENNIS FARRELL, AND THE AUTHOR.

The existence at the present time of a commission engaged in the much-needed and difficult task of revising the charter of New York City makes opportune a discussion of possible advantageous changes in the engineering organization of the city, as provided for in the charter. It seems particularly fitting that such a discussion should take place in a society composed, as is this, of members of the technical staff of the city. The most profitable discussion would doutless be had if all the remarks of the evening were made by engineers in the city's employ, since they are best fitted by experience and intimate knowledge to exhibit the strength and weakness of the engineering organization under the present city charter. There may be some slight advantage in having the discussion of the evening opened by one who is not an official or an employee, or even a resident of New York City. However this may prove, I will be so brief as to leave ample time for the members of your society to discuss the subject from the viewpoint of municipal engineers in

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the actual employ of New York City. And I may add that I hope the discussion will be full and free, since a frank interchange of opinion here tonight, followed as it would be by the still freer expression of opinion in a more private way during the coming weeks, could scarcely fail to have a markt effect on the future engineering administration of the city.

The municipal engineer, I hardly need say to such a gathering, is assuming an importance in modern life little dreamed of a quarter century ago. The rapid increase of our cities and towns in number and in population is surpast by the increase in the multiplicity and complexity of the functions which they are being forced to assume. The proper exercise of these functions demands the constant service of the most skilled engineers, chemists and biologists that this and foren countries can produce. It would be a waste of time to enumerate the many branches of engineering and allied science represented in the city government and in your society. Naturally many technical departments have been created. The question I wish to propound is whether the number of separate departments is not too great; or, if it be assumed that so many are unavoidable, then are they not altogether too independent of each other? To the latter part of my question I think there can be only one answer: The various municipal engineering departments should be coordinated to a far greater degree than at present. Personally, I think some of them should be either abolisht entirely or else brought together as bureaus of one central department. I am aware that this is a delicate subject and one that it would be inappropriate for me, at this time, to deal with specifically. I shall therefore leave it and take up, in a very brief and sketchy way, a few of the arguments for a more centralized engineering department for New York City. These arguments center around three heads: (1) The overlapping and interrelation of municipal activities and departments; (2) the unity of the city, even tho it be composed of five boros; (3) the need of a municipal program or a general plan of municipal improvements, to be followed thruout a long period of years.

You all know that of the city departments having to do with any branch of engineering, there is scarcely one that does not frequently find itself at a disadvantage because of more or less serious conflicts of jurisdiction with other departments. Where the actual conflict

of a given department with others is at a minimum, there would still be a gain if the work of all the departments were more completely in harmony. It is probably true that some clash of interest is inevitable, no matter how centralized the engineering work of the city might be, but obviously the impact and the friction would be lessened if a coordinate organization, under a single directing head (individual or board), could be substituted for the many independent boards, commissions and departments now bilding and operating public works in this city.

The division of the city into five boros has many decided advantages, particularly from an engineering viewpoint; but if New York is to be one in fact as well as one in name, many of its public works must be planned and operated as one great whole instead of as five more or less independent units. The need for unity in the matter of rapid transit has been conceded and is being acted upon, and so to some extent has the need for a single comprehensiv system of water supply. But what a deplorable lack of unity do we see, for instance, in so important a matter as main sewerage and sewage disposal for Greater New York, in reference to the pollution of the noble rivers, bays and beaches of the city! Many other phases of the desirability of more engineering centralization for the boros might be mentioned, but I must go on to my next topic, the demand for a municipal program, or a general plan for municipal improvements, calculated to meet the needs of the city for many years to come.

Every municipality, no matter how small and how few and simple its needs, should have a carefully framed municipal program for needed public improvements. This is an essential requisit if the wants of the people are to be met in the order of their importance and are to be carried out in a systematic manner. If a small town needs a municipal program, how much more is one needed for a city so large and with such varied needs as New York? You all know that if each department of New York City were to be given the appropriations that would be required to carry out the public works urgently needed today, the sum total would far exceed the limit of the bonded indebtedness. At present, each department asks for as much as it dares without too great risk of making itself ridiculous, and takes with as good grace as possible what the Board of Estimate allows. Each city department is forced, by the system now

in vogue, to consider its own needs to the utter exclusion of the needs of all other departments. Such is bound to be the case under the provisions of the present charter. With a central engineering department for the whole city, the requirements of the various subdepartments would be carefully considered in making up estimates, and the work of the Board of Estimate would be greatly simplified and could be done with more intelligence and in a more judicial manner than is now possible. Of course I am aware that the Board of Estimate has its own engineering department, and an able one, and that both the Board and its engineers represent the city as a whole, consider all its various needs, and meet those needs as best they may. But the Board does not and cannot have much to do with the actual formulation of plans, and it is in this that a central influence, and that a strong one, is needed to ensure that the needs of the city as a whole are being met.

What I have said may seem vague or at least very general in character, but my object has been to stimulate others to discuss the more specific phases of the subject. Some of these are: Would it be feasible and desirable for New York City to have, what it stands almost alone among cities in not having, a city engineer? Or if a city engineer be out of the question, might there not well be a Department of Engineering, composed of a Chief Engineer and a number of Department or Bureau Engineers? If either plan be practicable, to what extent could all the engineering work of the city be put under the direction of the City Engineer or the Department of Engineering? Would it be necessary, whatever plan might be adopted, for the City Engineer or the Chief and the Bureau Engineers to continue to occupy secondary places in the city government? That is, be under a Commissioner of Public Works, or a Department of Public Works, the latter having its Commissioner, over the Chief Engineer, and its Bureau head, over the Bureau Engineers? To what extent should each boro maintain an engineering department, partly or wholly independent of the engineering department of the whole city? These questions I leave with you, as well as the greater part of the evening, in the belief that they can best be discust and the time best used by the Municipal Engineers of the City of New York.

DISCUSSION.

MR. GEORGE S. RICE.—Gentlemen, I know you are pleased to have this subject brought to your attention and I think you all realize that the remarks made by Mr. Baker are very pertinent to New York. Probably no city has such a large engineering force under its control, nor is there any city which has such a variety. When you come to consider the great questions of water supply—the largest water supply in the world; the questions of rapid transit; the questions of sewerage and then sewage disposal—a subject that has attracted a great deal of attention, but about which very little has been done; and then the question of all improvements in the different boros, lying, as they do, one some distance out to sea, others separated from the main and fundamental portion of the city, Manhattan, by rivers, you can see that the problems which are to be considered are such as will probably not be considered in any one city, either on this side or on the other side of the water.

I realize that you, gentlemen, have probably strong ideas on this question. There is no doubt that Mr. Baker has exprest himself when he says there should be some co-ordination by which all departments should be brought under one authoritativ head, and I know that you will be very much pleased to enter into this discussion, many of you have probably thought a great deal about the subject and I hope you will express yourselves.

A MEMBER.—I would like to ask Mr. Baker his ideas as to any classification that he might make for the separation in the force of the Boro President, as to the duties that ought to specifically apply to that boro and to the engineering staff connected therewith, as regards local improvements, such as highways, etc., and also as regards general subjects which affect all the boros, such as water supply and rapid transit. I would like to ask whether he has made any separation or thought of any separation in that line?

MR. M. N. BAKER.—I have made no attempt of that sort. It would involve, as you all understand, a very considerable study to enable one not informed as to every detail to speak authoritatively on the subject.

MR. MAX L. BLUM.—Mr. Baker's paper falls strongly within the scope of our Society, since one of the clauses in our Constitution states that it is the purpose of our Society "To harmonize the work of the engineering staffs of the several departments of the public service."

In the recent investigation of our Department (The Public Works of Manhattan Boro), it was shown that many of the difficulties which we experienced were due to this overlapping of administrativ functions. The question of maintenance and repairs of

streets is not centered in the Bureau of Highways, but is divided among many departments. The Sewer Department makes openings and repairs streets. The streets adjoining the park system or connecting with the same are under the jurisdiction of the Department of Parks, while those along the water front are under the control of the Dock Department. The Water Department opens up miles of streets for high pressure fire service mains and other purposes. The Public Service Commission, thru a legislative letter of marque, converts the city into a series of gullies and abysses. For all these evils, incidental to the growth and progress of a metropolis, the hapless incumbent of the Boro President's office receives the entire volley of blame and abuse which a space-filling press can pour upon him. Our charter should really be so modified as to make him a *de jure* as well as the *de facto* official scapegoat for the sins of omission and commission of all other departments and bureaus.

Our Society has done much to bring about co-ordination. The Committee, under Mr. Lazarus White, establisht the relation between the various level data. We have a committee now to standardize asphalt specifications, and also one for sewer specifications. Moreover, the personal intercourse and discussions at our meetings of all the engineers of the many departments has tended to greatly minimize interdepartmental friction, and to bridge, tho unofficially, those gaps brought about by an imperfect city charter.

The idea of a Central Engineering Bureau appeals very strongly to an engineer. I have discust it with many and they unanimously favor it. It would have a very important function, such as keeping systematic records of cost and durability of various engineering structures, standardizing specifications and systematizing the keeping of records. It would have charge of all general work affecting departments as the testing of materials, the mapping and recording of subsurface work, the triangulation and mapping of the city, etc. It would conduct special engineering investigations, such as ascertaining the feasibility of constructing pipe galleries, and formulating traffic regulations. It would conduct the preliminaries of proposed public improvements, have charge of the engineering archives of the various departments, purchase all engineering and office supplies, decide questions of reciprocal responsibility between various departments and oftentimes act as arbiter between engineer and contractor, thus avoiding needless litigation. In fine, this central bureau would centre all responsibility for engineering matters which affect more than one department.

A MEMBER.—It seems to me some of the Departments, those which particularly relate to all the boros, might be co-ordinated to advantage. There is the Rapid Transit, the Water Supply, Docks and Ferries, and Bridges. On the other hand, the Department of

Sewers and Highways I do not think could be united to any advantage. The conditions presented in each boro are so different that each must solve its own problems for itself, and I do not see that any advantage would be gained by consolidation. In fact, I think it would be a disadvantage.

MR. RUDOLPH P. MILLER.—I believe that the centralization of engineering work of the City would have some advantages, as Mr. Baker has pointed out, but I also believe that for a large city like New York, the matter would be impracticable. The case is analogous, in many ways, to the engineering work done on a large railway system. Our railway systems, as a general rule, have their Chief Engineers; but the Chief Engineer's function is largely that of looking after new extensions and new work, and, perhaps, fixing the standards for the different divisions that are already in existence. I think the most effectiv organization and work, as far as the Engineer is concerned, is in the Maintenance-of-Way Department. In such cases the Division Engineers report to their Division Superintendents and only come in touch with the Chief Engineer when questions of standards are involved, the object being to have a uniformity on the different divisions as far as possible. So it is in the City Departments. The problems that arise in the Water Department, the Dock Department or in the other Departments, differ so very much that it would be better to have them receive individual consideration by these separate departments. I think an Engineering Department corresponding somewhat to the Chief Engineer's Department on the railroad would be the Engineering Department of the Board of Estimate, or the Finance Department. They have, to a certain extent, the power of final decision on most of the questions, since every engineering proposition arising in the City work is finally submitted to the Chief Engineer of the Board of Estimate, who passes upon it, more particularly, probably, as to its cost and its financial practicability and advisability. It seems to me it would be very difficult to get all the engineering departments co-ordinated. Something might be accomplisht in the way of co-ordination, however, if the suggestions that have been made by our Mayor are followed out by the Charter Revision Commission. They are the centralization of the Departments themselves, making fewer Departments, if possible, and in that way bringing about more co-ordination. I have in mind now the organization of the City of Philadelphia. There the City Government is divided into two large branches, both under the Mayor, each headed by a Commissioner,—one the Commissioner of Public Works and the other the Commissioner of Public Safety. Under the Commissioner of Public Works come all the Departments which have jurisdiction over new work or construction, and

over the maintenance of existing structures. Under the Department of Public Safety come all such Departments as secure public safety, such, for instance, as the Fire Department and the Bilding Department, or, as they call it in Philadelphia, the Bureau of Bilding Inspection. This latter Department has practically nothing in common with any of the other Departments, and yet it has an Engineering Division of considerable importance. In fact, I think the Engineering Division of the Bureau of Bildings is the most important part thereof, and yet I am not one who believes that the head of such a Department or Bureau should necessarily be an Engineer. I believe a good business man at the head of such a Department will probably accomplish more than an Engineer, especially if the head of the Department is subject to continual change. The head of an Engineering Department should be in a position that is not subject to change, so that uniformity should prevail thruout all administrations, provided, of course, that efficient service is always rendered.

MR. EDWIN H. THOMES.—I would like to get the views of members, whether they think it advisable for the Society to appoint a Committee whose function it will be to digest the suggestions made this evening and present them to the Charter Revision Committee.

MR. GEORGE S. RICE.—The Engineers of the Board of Estimate of the City of New York are the Engineers for the City who have an opportunity for observing the working of the City of New York as a whole, and I think it will be of benefit to the Society if Mr. Tuttle, of the Board of Estimate, would express his opinion about this matter.

MR. ARTHUR S. TUTTLE.—The important position occupied by the engineering staff in shaping the development and growth of the City has been given substantially increast recognition in recent years, and this occasion is a timely one for a discussion of its organization and for bringing out views concerning its more effectiv utilization which may be of assistance to the Commissioners now engaged on the revision of the Charter.

New York has had the benefit of four years' experience with departmental control and six years with boro control, in both instances under the general supervision of a central body. It seems to be accepted that the boro form of administration has been much more satisfactory than the one previously tried, but this result is at least partly due to the adoption of more direct methods for securing final action on proposed improvements.

The author of the paper, observing the situation from a point of view which those engaged in the service of the City are apt to lose, has evidently noted the failure of any previous plan to bring the entire engineering force of the City into such harmonious relation-

ship, that improvements, for the responsibility of which various branches of the service are charged, are carried out in such a way as to invariably meet the best interests of the City as a whole and subservient to the particular need of the branch of the service under which the work is actually done.

An appreciation of a failure to provide the desired co-operation of engineers was undoutedly responsible for the formation of our association and for its rapid growth, as well as for the appointment of committees to study the means of bringing about harmonious treatment of similar classes of engineering work by the various departments. Notwithstanding these efforts, the principles followed in design and construction present as much variety in the different boros and departments, as if there were no bond of unity between them. Just how to bring about the much desired harmony which the author appeals for, requires more careful study than the speaker has given the subject, but he has no dout that some such engineering organization will in time be brought about and that it will unquestionably be for the best interests of the City.

MR. GEORGE S. RICE.—Some of our speakers referred to Philadelphia, and I know that the question of co-ordinating the various departments has been considered there with great care.

In the city of Boston, the City Engineer exercises a central authority over the work, having charge of streets, pavements and bridges, tho there are several departments over which he has general supervision. Because of certain peculiar conditions existing there, such as the topography and the fact that certain towns and cities have separate systems of government—such as Brookline and Newton—which lie a few miles from the centre of the city of Boston,—it became necessary, with consent of the State Legislature, to create separate Commissions which take up the questions of water supply, parks and drainage, the cost of all improvements being assessed upon the separate towns. This method, however, is inapplicable to New York, because of our subdivision into boros, etc. In our department, the Public Service Commission, we have in the past been confronted by the problems mentioned to-night as we came into direct contact with almost every municipal department, thru the necessity of changing sewer, water, gas and electric mains, changing the grade of streets, and in many instances the streets themselves. The legislature realized the necessity of vesting the power in one central authority. At first the various departments viewed us as interlopers, but now, largely thru the influence of this Society, all departments meet us in a spirit of professional fellowship.

MR. ALBERTO SCHREINER.—I would like to make a few remarks in answer to the gentleman from the Bronx, who mentioned a few minutes ago the question of sewerage. It is very true that the

sewerage question in each one of the boros is entirely distinct and separate from that of other boros, due to its topographical features. It is true that as far as the systems are concerned, each might work advantageously by itself without any regard to the systems of other boros, because, with the exception of the Boros of Queens and Brooklyn, the boros are entirely divided by waterways. In working out these sewerage systems, nearly every Boro has a different rate of rainfall, and uses a different percentage of run-off for areas of the same character. The Engineer in one boro considers a bilt-up area; the Engineer in another boro considers a suburban area. One uses 60% of run-off and the other considers 40% as being sufficient. One works on the basis of 3 inches of rainfall and the other of 1½ in. Not only this, but even in details they have different opinions. One allows certain minimum grades and another allows different ones. With the maximum grades the conditions are the same. The taxpayer in one boro is charged $60 per lot for a sewer; in another boro he is charged $250. In one boro the concrete is mixed dry; in another it is mixed wet. In one boro the sewer has to be of reinforced concrete, the specifications insisting upon that construction; another boro uses brick sewers only. Certainly there is no harm in this. Another thing, one boro submits to the Board of Estimate a certain plan, and a certain friend of ours looks at it and says: "It's very nice; I see you have flush tanks." "Yes." "Why do you have flush tanks." "All right, good argument." Along comes another Engineer of some other boro with another system without flush tanks and he is asked, "Why don't you use flush tanks?" "Well, I do not think we should have flush tanks." "Why not?" "I do not think they will work there; they are good only for short distances and are very costly; they are not kept in proper condition; sometimes they work every six hours and sometimes every forty-eight; we can flush them better with a hose." Then the poor Engineer of the Board of Estimate is between two fires.

Now, all this shows, as far as Greater New York is concerned, that there is no uniformity in engineering work. But there are other considerations. The Sewer Department to bild a sewer rips up the street to-day and repaves it to-morrow. A few days after the Water Department comes along and tears it up again. The Highway Department paves a street today and a few days after the Sewer Department tears it up again to put in a sewer.

It would certainly be of much benefit to have all these different Departments under one head, an individual, or an Engineering Board, as suggested by Mr. Baker, but the area of the Greater City of New York is very extensiv and we come to another difficulty:—

It has been suggested at different times that certain improvements be passed upon by an expert or a Board of Experts. But the

point is that certain local conditions have to be considered. Some localities are developing very slowly and some very rapidly, so rapidly that the improvements cannot keep apace. Now, it is necessary that those localities which are developing very rapidly, should get some improvements even at the expense of good engineering. The people are investing their money there, they have to live there, and New York City's population must find place in which to live, and to be able to live in those places they must have some improvements, if only of a temporary nature. Is it not proper in such cases to work out certain improvements on certain lines, which from an engineering standpoint may not follow the generally adopted standard?

If we had a Board of Experts or a central Board of Engineers, they would, considering the City as a whole, disregard those smaller localities and retard their development.

A MEMBER.—It might be interesting to note that The Bronx is a unit against centralization. We have had quite an experience of it there. We had seventeen years as an annex to Manhattan and then we had three years of independence, which was markt with success. Then we had four years, I think, of centralization, where we got nothing again, and we have now had thirteen years under the Boro President and the Engineers. We had nothing but clashing during centralization. The Highway Department was against the Street Cleaning and the Street Cleaning was against the other Departments, and we had a conflict of contracts. In one particular we are fortunate. We have a Boro President who has been there for thirteen years, and, more important than that, he is an Engineer himself. He keeps us straight, and we think we have centralization in him, and if he does not do what we desire, the remedy is ours at election time. On that basis the bilders and land speculators of all descriptions can go to him. They know where to find him. If they have any grievance they lay it before him. Under the old regime we had merely a Deputy there. They would go to him and state their grievances and were referred downtown, and it took them three or four days to find the proper authorities, and then did not accomplish what they desired.

MR. ROBERT R. CROWELL.—From 1898 until 1902, New York City had centralized government. During that period the Boro of Queens had three or four deputies in the Highway Department, and one in the Sewer Bureau. The Commissioner of Sewers and the Commissioner of Highways, having their headquarters in the Boro of Manhattan, practically never saw the Boros of Queens or Richmond. It is fair to presume that with centralized government the greater portion of the heads of departments would be located in the Boro of Manhattan; thus taking Manhattan work as a standard. There are several boros which cannot afford to take Man-

hattan work as a standard. For instance, in the Boro of Richmond, or in the Boro of Queens, and possibly a portion of the Boro of Brooklyn, there is a great amount of land which is relativly cheap, and people are flocking there by the thousands. It is absolutely necessary that these people have some kind of temporary improvements. In consequence of this, the improvements made must be made very inexpensivly, because under the Charter the City can assess a man for improvements only about one-half of the assessed valuation of his property. In the Boro of Manhattan the assessed value per lot would be a very large amount, so that costly improvements can be made, but in the Boro of Queens it is a very small amount, where some of the lots are only assessed at $150, consequently we could not make any improvement which would cost more than $75 per lot. The Engineers, therefore, in these boros must devise some means by which they would be able to give the residents some improvements at the present day. Under centralized government, dominated by men from Manhattan, and with Manhattan work as a standard, plans would be adopted for large size sewers, which would not be required for 25 years or more. When a small section of the boro petitions for sewers the authorities would point out the fact that it would be necessary to put in 4-ft. sewers, with the explanation that they would want these large size sewers 25 years hence. If they put in 4-ft. sewers they would be confiscating the man's property. For the next fifteen years probably a 12-in. sewer would be sufficient for a certain section, and at the expiration of that time the property could afford the large size sewer.

A macadamized pavement which costs from 60 to 90 cents per square yard, will suffice for a great portion of the boro. We would find that the centralized authorities would advocate putting down a granite block pavement on a concrete foundation and filled with pebbles, at a cost of about four dollars per yard, when for a number of years the 90-cent pavement would answer every requirement.

Now, the authorities in the Boro of Manhattan have not, nor would they have, any interest in the suburbs of these young boros, and probably would not see them once in six months. The only way the people of these boros could get to them would be to come over to Manhattan, and this means an hour's ride, and probably when they arrived at the office they would find the man they wished to see was absent. They might put in a petition, which might be investigated in a month or six months, but in the meantime no improvement is made. I myself think that the people who are living in the boro, who are in the boro at all times to hear these people, are the people who are most interested. I do not think you could get a man in Manhattan interested in the Boro of Queens

or the Boro of Richmond to any great extent, as they have not sufficient interest there. At present, when people ask for public improvements they go directly to the President of the boro, who is easily reacht and vitally interested in the boro, because if he does not do what is proper the people will certainly dispense with his services. Consequently he endeavors to do as much as he possibly can for them, or as much as the Board of Estimate and Apportionmen will permit him to do, and I, for my part, do not see where centralization is going to help these different boros. We have large departments, like the Department of Water Supply, Gas and Electricity and the Rapid Transit Commission under centralized government, and possibly in better condition than they would be under boro government. Of course, they have been given a great many liberties which none of the boro departments have received. We find, in these different boros that the improvements most desired by the people are the local improvements which they have to pay for themselves, and consequently I think the people best suited and best fitted to look after their interests are those people who are directly on the ground and interested in the welfare of the boro which they represent.

MR. WILLIAM R. HILLYER.—The remarks of the last few speakers seem to have gone a little astray from the original question, altho they are good in their place, as the same principle may apply to a certain extent to the Engineer members of a City Administration. While it might not be true that an Engineer in a Central Board in Manhattan or a central engineering office would treat of the considerations involved in problems concerning one of these smaller boros, as, for instance, the Boro of Richmond, with the same indifference as the average Commissioner, still, at the same time, altho he may be a brighter man, perhaps, than the local commissioner is apt to be, he is handling so many large things that the little things needed by the local considerations would perhaps be overlooked. The analogy to a railroad system, which Mr. Miller brought out, imprest me in this way: That the idea of the Resident Engineer or Division Engineer has for its value the fact that his interests are in the territory in which he resides and which he serves, and that, altho he may have to submit his plan to some Central Engineering Bureau, he has based his efforts on that subject upon the needs of his territory. It might be a good idea, in connection with this matter, that the Central Engineering Board be composed of the ranking or Division Engineers in charge of the engineering works of the boros.

A MEMBER.—I agree somewhat with a few of the earlier speakers in that the present conditions and the ability to secure improvements in the various boros are superior to what they were in what they

called the Centralized Administration of 1898-1902; but, altho in the Department of Highways and the Department of Sewers during that time we had the Commissioner with a Central Bureau, there was really no more co-ordination between the Engineering Bureaus of the various boros than there is to-day. They were separate. The Administrativ Office was a Central Bureau and at least they did not succeed in getting their local improvements as readily as they do now. There was no engineering head and no co-ordination between the various boros such as Mr. Hillyer tried to point out.

Mr. Henry W. Vogel.—I did not intend to speak here to-night, but there has been so much said about the satisfaction and dissatisfaction with a central and a local plan of administration, that I desire to call the attention of the members to the fact that as far as I am aware, very few municipal engineers were consulted in relation to the engineering features of the Charter.

An experience of over thirty years with municipal affairs convinces me that the interests of the city would be best subserved by having the plans for streets, sewers, transportation facilities, docks and parks prepared by one department; the execution of the plans might be left to Boro Presidents or local boards.

Mr. John T. Fetherston.—There is only one thing I can add to what has been said about the present subject, tho it is hardly germane. I think under centralized government the Boro of Richmond had only two sweepers.

A Member.—Even if we do not have centralization, I do not see why we could not have a little more co-operation between City Departments. I think it must be evident to any Engineer in the City that there is a good deal of duplication of work. For instance in regard to the survey of Jamaica Bay,—Queens Boro has covered it; the Dock Department has surveyed most of it; other City Departments have done some work there, and the Jamaica Bay Improvement Commission has surveyed it, and now I understand the Government is going to take its turn at it.

Mr. Dennis Farrell.—There is in the proposition of the revision of the Charter for the betterment and improvement of the City, one matter which is of great importance, and that is the surface of the streets. We know how much trouble the Boro of Manhattan has had during the last year or two. The Boro Presidents should have more control over the surface of the streets, so as not to be hampered as they are now and have been by other independent branches of the City Government.

The questions of the condition of the streets in which the people travel are more to be considered, I think, than most other questions. If there is an opening made by the electric companies who want to put down subways, or put in electric ducts, it frequently happens

that the subway company sends its orders to the paving company to repave the street. The paving company does not notify the City, nor does the subway company. The result is that the paving company puts in any kind of material, and it is only afterwards that the Highway Department discovers that the repair has been made.

The Gas Companies, the bilders, and the Department of Water Supply are other sources of annoyance. They open places in the streets and it is only after a long time and after causing considerable annoyance that the repairs are made, and sometimes they are not made at all by them, and no one knows who made the opening. Thus it remains for a long time, until the City finally has to do the work itself.

Those things are very hard to remedy. They keep the streets of the City continually in bad condition, and cause a great deal of annoyance to the people, and nobody knows anything about them.

In all cases, if the surface control and the work on the surface of the streets were entirely under the head of a Boro President, or under a Commissioner of Highways, it seems to me that he would be responsible for all the conditions, and all these annoyances and stoppages that occur now, sometimes running into months, would not occur, and a more direct responsibility would result. With a sub-division in the boros of that sort it would seem to me that the Boro President or the Commissioner could be more easily held responsible.

MR. M. N. BAKER.—In the discussion much has been said about centralization. It would be too bad if a wrong idea as to centralization were carried away from the meeting, and especially the idea that anyone favors taking the control of purely local matters away from the localities directly concerned. In a great City like this, composed of many communities which, once widely separated, have been gradually knit together with the growth of population, and which still differ in many respects, it is obvious that there are many questions which should be handled in a strictly local way, while others should be dealt with broadly, since they are general in character and apply to the whole city. Since Greater New York exists in name, it is desirable that it should exist in fact. It should be one in those things in which there may be unity, but may still have diversity in purely sectional or local matters. But there are many great fundamental needs common to the whole community: Rapid transit is one; water supply, to a large extent, is another. One need not study rapid transit long before seeing that other branches of the City Government ought to co-operate with those which are responsible for the provision of rapid transit. For instance, the Bridge Department should co-operate with the Public Service Commission in making adequate connections between the bridges, the subways and other transportation lines of the city.

Reference was made to certain conditions that prevail in Boston and vicinity. Some of those conditions have been met in a way that serves to illustrate a number of the broader phases of centralization of administration. A number of Massachusetts cities and towns have been united as a Metropolitan Water and Sewerage District, under one Board. The different municipalities are perfectly independent so far as the administration of local water supply and local sewerage is concerned. They are united in the provision of a general water supply for the district, and in the provision of trunk sewers and of means for the final disposal of sewage. Here, in connection with sewage and sewage disposal for Greater New York, there is great need for a comprehensiv plan for the sewage disposal of New York City as a whole, instead of permitting it to go on as it has gone on in the past, in a very random and haphazard condition, not only from boro to boro, but, to a very considerable extent, within each boro itself.

We may go further afield, if you will. We may go across the Atlantic to London. In the center we have, in point of population and of area, a tiny old city. That is the original City of London, with now only some 25 000 people who are actual residents of the City, whereas a few years ago there were 100 000 or even more. There are, however, surrounding that central part, a great many separate boros, each a consolidation of many small bodies. That consolidation took effect about the time the consolidated Charter became effectiv here. Twenty-seven boros, the City of London and the City of Westminster, with a population of 6 000 000, are combined for certain purposes under the London County Council. The London County Council has a Chief Engineer. The Council has charge of the main collecting and trunk sewers, and the great disposal works on the Thames. It also has charge of certain main highways and other public works for Greater London, but the administration of most of the streets in the various boros, of the local sewers and a multiplicity of other local affairs, lies with the boro Governments, each of which has its Boro Engineer. The water supply of Greater London, after having been, since its early introduction centuries ago, provided by private companies, which continued until there were eight companies supplying London and surrounding municipalities, has been finally taken over by a Central Administrative Board. The water supply, not only for the area comprized under the jurisdiction of the County Council, but some of the surrounding municipalities, is now all in the hands of a Metropolitan Water Board, with a Chief Engineer and with Division Engineers for different portions of the Water District.

These serve merely to illustrate some features of the subject and some of the broader aspects of it. Two things must be kept distinct.

There should be comprehensiv plans for everything pertaining to Greater New York as a whole, and yet individual attention must continually be given to things that are purely local and should be administered locally.

It is to be hoped that while the Charter Revision Commission is making investigations looking to amendments of the present Charter, it will be made to feel that engineering work and the engineering departments of Greater New York are important. These departments should be heard from. Their ideas deserve consideration, and I know of no better agency for bringing them home to the Charter Commission than this Society. Whether this be done by a written communication to the Charter Revision Committee, or at a hearing, or in whatever manner, by all means do not let the opportunity pass for impressing upon the Charter Revision Commission that the great problems of the City are engineering problems and that they must be met and solved by the Engineer.

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.

Paper No. 36.

PRESENTED NOVEMBER 27, 1907.

THE SOUTHERLY EXTENSION OF NEW YORK CITY.

BY MR. HERMAN A. RUGE, MEMBER OF THE SOCIETY.

WITH DISCUSSION BY

GEORGE S. RICE, ALBERT E. HENSCHEL, ALBERTO SCHREINER, AND THE AUTHOR.

In bringing before you the subject of the Southern Extension of New York City, it will be interesting in the way of an introduction to notice the fact that the destruction of land, as well as the extension or making of new land, by the forces of nature alone is going on at all times and all over the world. Land also rises in some regions of the world and falls in others; for instance, we know that the Coast of Norway is steadily rising, and that our Atlantic Slope is steadily sinking at the rate of nearly 1 in. in 100 years. Sometimes we hear that ilands have disappeared into the ocean and new ones have suddenly appeared, caused by volcanic eruptions.

We see in the present limits of New York City rapid changes made by the tidal currents along the southern shore of Coney Iland and Rockaway Inlet, where, at the latter location, land is being made at the rate of 200 ft. per annum.

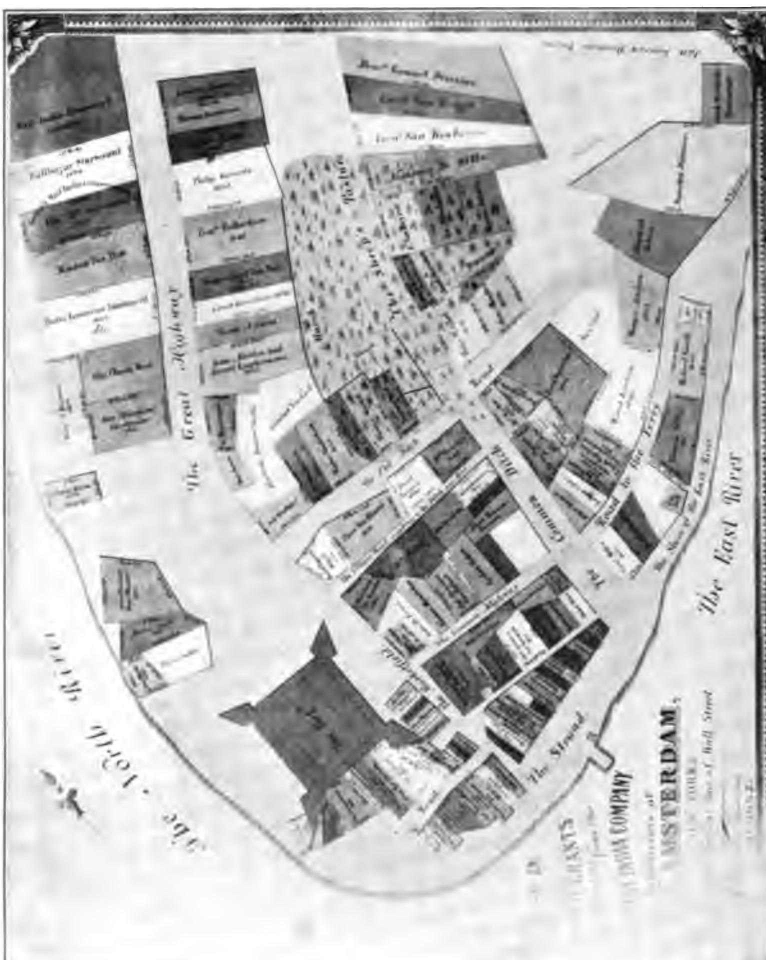
Human force, guided by engineering intelligence, is working steadily and energetically for the protection and extension of land all over the earth. On a very large scale such engineering works for protecting the coast are continually being constructed in Holland. The shallow Zuider Lake—of many square miles area—has

been laid dry and is now being cultivated for farming purposes. At Galveston, Texas, the level of the city has been raised and a protecting sea-wall bilt only a few years ago.

I will divide this paper into three parts and show you first, briefly, what has been done in some other countries in the way of reclaiming lands under water or extending city limits. In the second part I will show what is going on by natural forces within our city limits, what has gradually been done by the city's inhabitants and what is proposed and in progress of construction, and here I include my own plans and proposals publisht in 1893, partly adopted by the U. S. Government and now in course of construction. In the third part we will take a glance at the possibilities of such a southern extension of the city limits, which will prove of benefit, not only to our metropolis and to the community at large, but very especially to the city's treasury.

I.—As examples of what other cities are doing in the way of extending their city limits, we find that almost all large cities, especially commercially growing towns, are eagerly engaged in extending their limits, if they have not already done so. Paris has regulated the Seine, London has constructed the Thames embankments, Rome has regulated the bed of the Tiber, and Vienna the Danube, thus reclaiming vast lands, which were annually subject to inundations. Thus, to-day, the danger of inundation to the suburbs of Vienna is no longer to be feared. Budapest has constructed a system of bulkhead walls on each side of the Danube and has gained new space for traffic and shipping. The large works of regulating the Danube at the "iron gate" and making the river navigable for ocean-going ships may be known to many of you, as several prominent American engineers took part in this work. The Town of Zürich in Switzerland reclaimed a large territory from the lake and made an immense profit from the sale of new lots, besides securing land for parks and beautiful shore roads.

II.—I might mention many more instances of foren works of city extensions, but will turn now to our own neighborhood. Looking at the geological map of the Hudson Valley, we see how the deep cut of the river when reaching out into the ocean has a deep cañon toward Sandy Hook light-ship. Also toward Jamaica Bay there is an old cañon visible. The shipping has to follow to-



MAP OF ORIGINAL GRANTS BY DUTCH WEST INDIA COMPANY TO INHABITANTS OF NEW AMSTERDAM, BELOW WALL STREET, BEGINNING IN YEAR 1642.

PLATE 45.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
RUGE ON SOUTHERLY EXTENSION
OF NEW YORK CITY.

DUKE'S PLAN OF NEW AMSTERDAM, SHOWING CONDITIONS EXISTING IN 1661, JUST BEFORE THE NICOLL CHARTER.
(This plan shows a ditch along line of Broad Street, which was later filled up, at the foot of which the Wet Docks were bilt. (Original at British Museum.)

day the cañons and the peculiar round-about circuit of the old fissure of the Hudson in order to enter our harbor. The dredging of a shorter, less dangerous, watercourse is now under way by the Government of the United States and will shortly be finisht.

A very prominent case of the reclamation of land by the city is now going on at Riker's Iland, where the new made land will amount to 242½ acres, which will make the old iland of 87½ acres have a final acreage of 330 acres.

The Jamaica Bay has been considered by the city authorities worthy of improvement for shipping purposes, and I give here a copy of the cost of the proposed improvements by the Commission and their Consulting Engineer, Mr. William G. Ford. On the map we see what the Commission proposes in the way of new docks, waterways and city lots, which represents a very large piece of work.

COST OF IMPROVEMENTS (EXCLUSIV OF ENTRANCE TO HARBOR).

(From Report of the Jamaica Bay Improvement Commission, submitted May 31, 1907.)

281 500 000 cu. yd. of dredging, at 12 cents per cu. yd.	$33 780 000
301 975 lin. ft. of bulkhead, at $25 per ft.	7 549 375
Engineering, inspection and administration, estimated at	1 000 000
6 800 acres of land, bought at $700 per acre	4 760 000
Total estimated cost	$47 089 375

To balance this expenditure there would be 15 920 acres of reclaimed land completely enclosed within bulkheads, which at but $5 000 per acre would aggregate in round numbers $80 000 000, together with one of the most extensiv of deep water harbors, capable of accommodating over one hundred and fifty (150) miles of vessels.

It would appear a reasonable proposition that as the work progrest the city could realize a profit upon some of the lands reclaimed, and turn the moneys thus acquired over to the improvement fund.

An annual expenditure of only $3 000 000 to $4 000 000 would be required at the beginning of the work.

As to the subject second in order, the acquiring of dock property, etc., in the boros, except Manhattan: The writer would recommend the continuation of the City's acquisition of available shore front south of Erie Basin (except that already highly developt), by methods similar to that of the Department of Docks and Ferries, whose policy is heartily endorsed.

This is the only recommendation he feels he can make with propriety at this time, as the problem first in order, Jamaica Bay, has necessarily absorbed most of his attention during the very limited period given for the consideration of such important subjects.

In conclusion the writer would recommend that the improvement should be done as a whole, whether it be done entirely by the City or by the City and individuals combined.

That, should the City of itself feel it unwise to develop all of these lowlands, in no event should it fail to acquire the waterfront and a zone deep enough to control the first two blocks inshore.

That it should adopt, with the approval of the War Department, some definit plan of interior improvement, capable of meeting the requirements of the present generation, without circumscribing those of the ones to follow, and that it should in the near future prescribe regulations necessary for its enforcement.

Respectfully,

WILLIAM G. FORD,

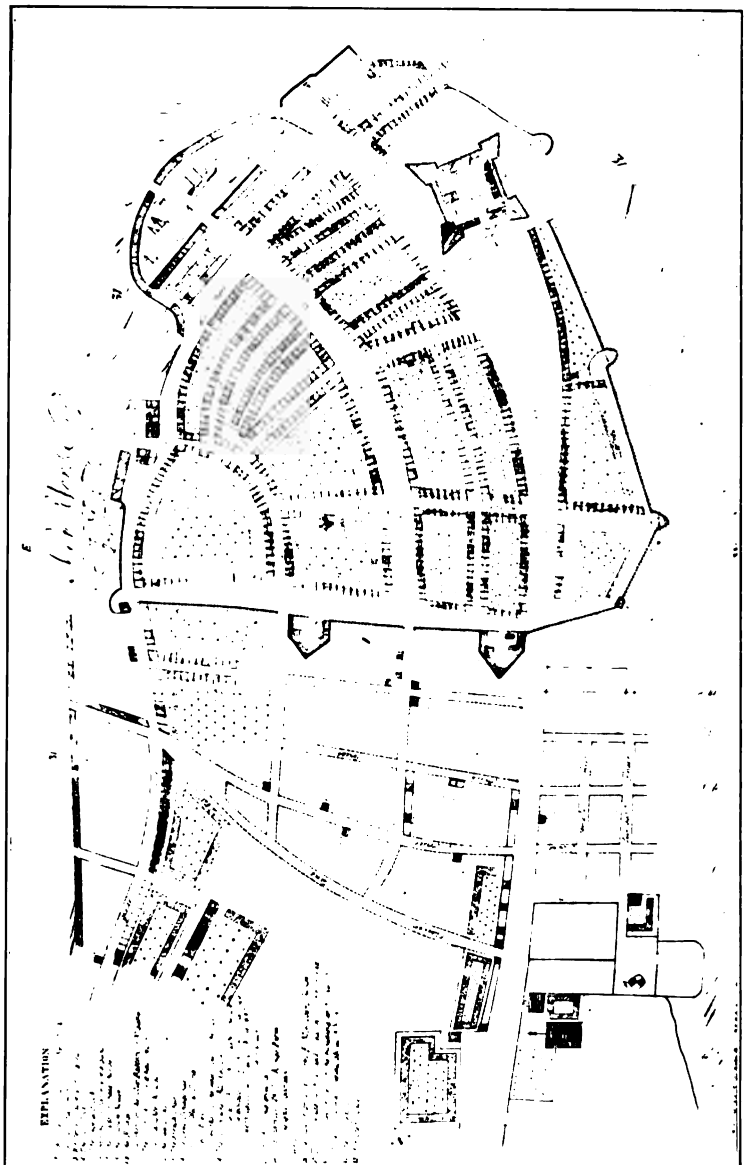
Consulting Engineer, Commissioner.

NEW YORK CITY, May 27, 1907.

From the plan of the inlet of Jamaica Bay, the movement of the Hook in a westerly direction can be seen according to government surveys made at different periods since 1841, and from these data we find that the ocean current is making land by bilding up the Hook in a westerly direction at the rate of 200 ft. per annum.

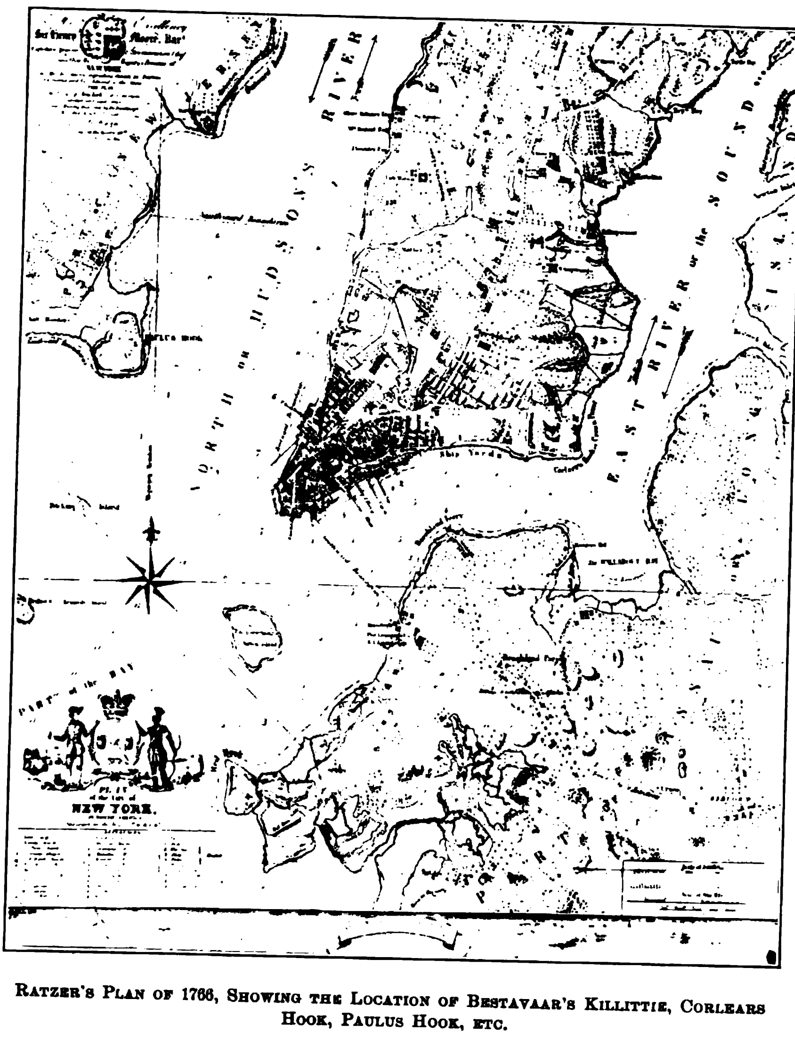
The following maps of New York since the year 1642 give a very clear conception of the development of our metropolis and show how watercourses have been turned into streets and how swamps, ponds and marshes have disappeared and have made room for valuable city lots. Also the waterfront has changed with the years, and the shore-line has been pusht out further and further

PLATE 46.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
RUGE ON SOUTHERLY EXTENSION
OF NEW YORK CITY.



MILLER'S PLAN OF 1695 (ORIGINAL AT BRITISH MUSEUM).

PLATE 47.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
RUGE ON SOUTHERLY EXTENSION
OF NEW YORK CITY.



RATZER'S PLAN OF 1766, SHOWING THE LOCATION OF BESTAVAAR'S KILLITTIE, CORLEARS HOOK, PAULUS HOOK, ETC.

until the Government of the United States thru its War Department has fixt the bulkhead and pierhead limits for extension.

I will now show you the plans for the Southern Extension of New York City (Manhattan) just as I worked them out sixteen years ago and submitted them a year later to the Hon. Thomas F. Gilroy, then Mayor of the City, and to Mr. Andrew H. Green, the Father of Greater New York. Both gentlemen took great interest in this work. These plans and estimates were publisht in 1893 in the New York *Times* and in the New York *Press*. I may mention that a high official of the War Department took a special interest in them, and he told me so himself. Later the U. S. Government extended the bulkhead lines of Governor's Iland, following very closely these propositions, as you can see later by comparing the Government maps of to-day showing their extensions, with these plans of sixteen years ago. To-day the extension of Governor's Iland is well under way, the sea-wall is finisht and the filling in of the land is rapidly progressing.

The ideal plans of a greater New York with rapid transit in more than one direction would certainly be materially helpt along by the adoption of these plans for a southern extension of New York City. Such a large scheme can only be done by the city for the benefit of its citizens. The making of the land, the bildings, the piers, the large water frontage, the bridges, streets, sewers, etc., would keep the various Departments of the City of New York busy and would give employment to thousands of idle hands for many years to come, and the city would, in the end, gain largely in wealth and public property. The new lands would find purchasers at the real estate exchange faster than the land could be made to appear above water.

The whole filling in can be accomplisht in three to four years. It is chiefly the shallows which should be filled in, the mean depth being about 30 ft. below low water mark. The new piers and bulkheads of nearly 3 miles would bring a large income to the city.

The Plan in Detail.

This proposed extension would extend southerly from Battery Park and from the present South Ferry. It would include Governor's Iland and then extend beyond on a shallow ground to a point, in a southerly direction, opposite Bedloe's Iland and the Statue of

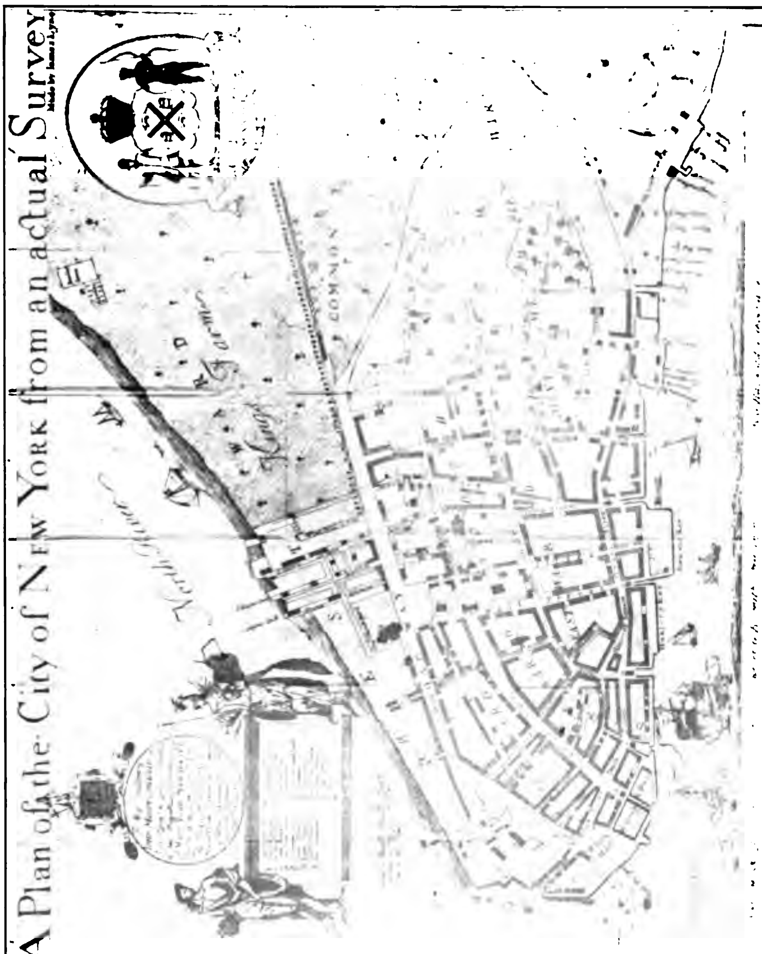
Liberty. The new land would be made of material obtained by dredging other portions of the Bay, supported by stone masonry bulkheads. There are many places in the Bay, even as far out as the water channels out into the ocean, the Shrewsbury River, etc., where a deepening of the water by dredging would be of great advantage to shipping, but where it is not done for fear of the heavy expenditure involved. With this plan all this dredging would cost the Government of the United States nothing. The length of the extension of the new land would be about 2 miles and the width about ½ mile. The total area of made land, including Governor's Iland, would be about 522 acres. This would be disposed of as follows: For parks, extension of Battery Park, 10¼ acres; new Southpoint Park, 41¾ acres; for the Grand Union Station and bridge abutments, 20 acres, leaving for bilding purposes, including Governor's Iland, with streets and avenues, approximately 450 acres.

The total length of the new river frontage would be 22 500 ft., or 4.2 miles, giving for piers, bulkheads, ferries, etc., exclusiv of parks, 14 700 ft., or about 2.8 miles. The new South Ferry would be located about 1½ miles further south. The elevated railroads would pass around the new South Ferry in one continuous line, without shunting. Two new bridges would be constructed to connect New York with Long Iland and New Jersey—a "south bridge" across the East River to Brooklyn and the "giant bridge" across the North River, the two bridges forming almost a continuous line.

We would have a rapid transit on a really grand scale to the south, to the east and to the west, and thru traffic from east to west. We would have north junctions with the Manhattan Elevated, the New York Central Railroad, the New York Subway, and south junctions with all boats from the new South Ferry, the Central Railroad of New Jersey and Staten Iland. We would have east junctions with the Long Iland Railroad and Brooklyn elevated railroads, and west junctions with the West Shore and Hudson Railroad, New York, Ontario and Western Railroad, New York, Susquehanna and Western Railroad, New York, Lake Erie and Western Railroad, New York, Delaware, Lackawanna and Western Railroad, New York, Pennsylvania and Western Railroad, New York and Lehigh Valley Railroad and Central Railroad of New Jersey.

We would have a direct thru connection from Long Iland to all

PLATE 48.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
RUGE ON SOUTHERLY EXTENSION
OF NEW YORK CITY.



BRADFORD'S PLAN OF 1728, MADE BY JAMES LYNE (ORIGINAL AT NEW YORK HISTORICAL SOCIETY.)

parts of the west and a Grand Union Station in New York City, from which all express trains to the south, east and west should start.

Navigation would secure improved facilities from new and convenient water frontages on the East and North Rivers at points where most needed. The waterways would be deepened wherever necessary, and the East River would be kept at more than its full width, thus giving ample room for the shipping and for the flow of the tides.

The value of the made land adjoining New York City would vary between $25 000 and $75 000 a city lot containing 2 500 sq. ft. Allowing one-half of the made land for streets, public places, etc., there would remain 4 050 city lots at an average price of $50 000 per city lot, or a total land value of $202 500 000. The property from the Battery toward the City Hall can only profit and will most certainly be improved by this southern addition of land and railroad traffic. There will be more business brought to its central position than at present.

The estimate of profits and of cost of construction gives the following chief items:

Value of 4 050 city lots on new land at $50 000......		$202 500 000
Value of new river frontage, exclusiv of parks, 14 700 ft., at $600..................................		8 820 000
Total value		$211 320 000
Cost of constructing new land—stone embankment, material and masonry for bulkheads	$7 175 000	
Filling in from dredging—39 000 000 cu. yd. at 25 cts....................	9 900 000	
For additional foundations............	3 375 000	
Compensation for existing privileges from South Ferry to Wall Street...	1 500 000	
Interest on capital during construction, items not foreseen, engineering supervision, dredging machinery, etc.	4 500 000	
Total cost for making new land........		$26 450 000
Leaving a profit of..................		$184 870 000

This immense profit could be used for constructing rapid transit improvements for the City of New York on a very large scale, for instance:

South bridge over East River, with 10 tracks	$10 000 000	
Giant bridge over Hudson River, with 10 tracks	50 000 000	
Approaches	5 000 000	
Extras, interests, engineering, etc.......	16 000 000	
		$81 500 000
Leaving a sum toward construction of rapid transit to the north of New York of		$103 370 000

The abstract of this detailed estimate is very conservativ, inasmuch as the prices for construction are higher than the contract prices of today, and the land valuation for such location as this represents may be termed "fairly low," for higher prices are paid very eagerly in good localities between the Battery and City Hall.

In the estimate for improving Jamaica Bay, the price for dredging is estimated at 12 cts. per cu. yd., and contractors are taking such work today at 18 cts. per cu. yd. This estimate for the bulkhead walls is about $30 per lin. yd. higher than Mr. Greene's (late Chief Engineer of the Dock Department) publisht price for similar work done by that Department.

This establishes the fact that probably the profits would be considerably larger than these estimates give them.

III.—Having shown in this short statement how the City could earn in a few years a capital of nearly two hundred million dollars, I wish to come to the conclusion of this paper by making some suggestions as to the possibilities and as to what might be done in the way of improvements with such means at disposal.

The governing principle would be that the City would do everything and would receive all the profits. This condition would make easy the task of obtaining a charter, necessary for such work, which charter would require legislation from the State of New York and from the legislature in Washington. No private person or company could in these days obtain such a valuable charter.

PLATE 50.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
RUGE ON SOUTHERLY EXTENSION
OF NEW YORK CITY.

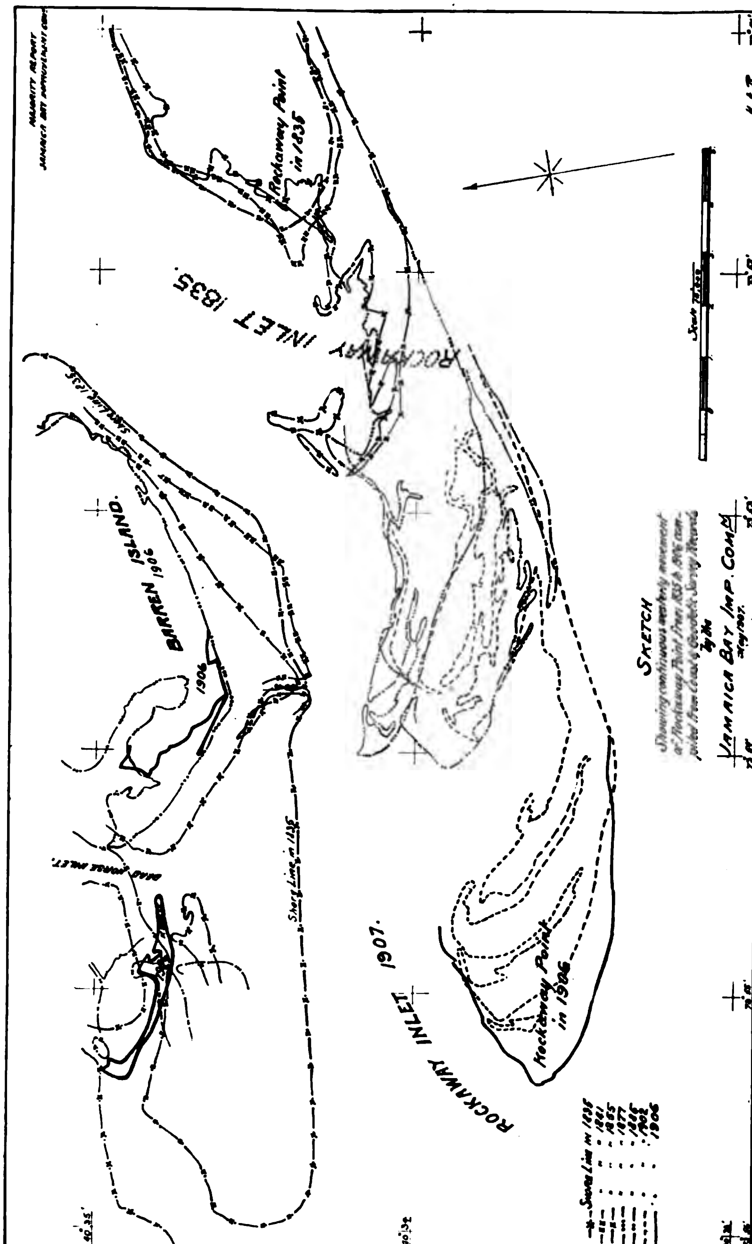
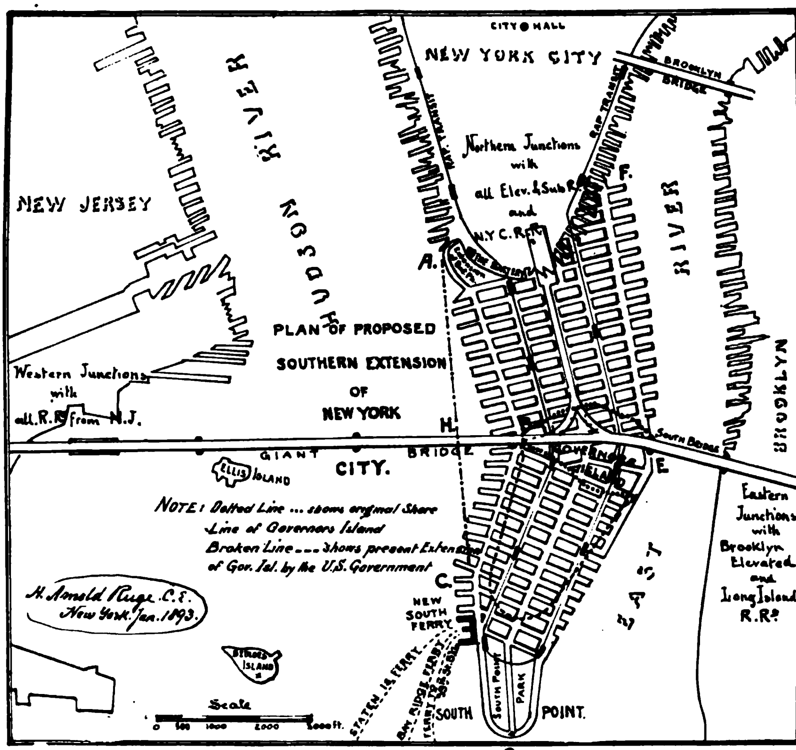


PLATE 51.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
RUGE ON SOUTHERLY EXTENSION
OF NEW YORK CITY.



PLAN OF PROPOSED SOUTHERN EXTENSION OF NEW YORK.

All the new made land should permanently remain the property of the City, who could lease it on long terms, of say 99 years. Then after the expiration of such lease all the property would revert to the City at an enormously increased value ready for a new sale on lease or on annual rental.

A construction company should be formed with a banking syndicate, fixt by charter, to manage the construction, furnish the money if necessary at a fixt rate of interest, and receive a percentage for managing all details connected with the work. The construction should be more rapid by such a company than by the present slow red tape system of City work.

All debentures would be paid from the sale of some property on lease ahead of construction, or by issuing bonds redeemable after a few years, when the sale of land is taking effect.

All dredging and other machinery, as boats, steamers, scows, tools, pile drivers, etc., would be the property of the City and be turned over to the Department of Docks and Ferries when the work is completed.

The total amount required for construction is about \$30 000 000, or 30 per cent. of the final profits.

When the land is being made, care could be taken to assist the U. S. Government authorities to deepen water channels where required.

The taxable value of such new lands for the City would be a very desirable annual addition, and would be soon equal to the present taxable values from the Battery to Chambers Street. The enormous value of such an acquisition to the City's Treasury can be roughly estimated by the following data. The value of land and bildings from the Battery to Grand Street is today, according to the publisht data of the taxation for the year 1907:

\$507 156 350	for land value.
\$219 472 360	for bildings.
\$726 628 710	total valuation.

This is the valuation made by the experts of the Department of Taxes and Assessments of the City of New York, and these valuations represent only 60% of the real salable value. Grand Street is higher uptown than Chambers Street, and we can safely take

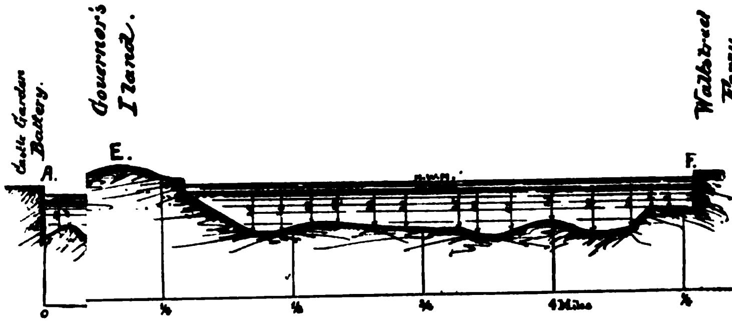
the above sum of 60% as being equal to the actual value from Chambers Street to the Battery, *i. e.*, $750 000 000, as being also equal to the value of the future southern extension of New York City.

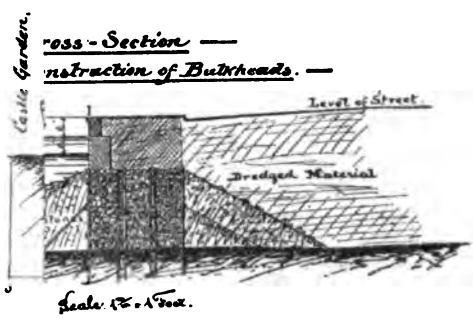
Enormous advantages to traffic could be derived, as stated before, by constructing the two large bridges, one across the East River and the other across the Hudson. Instead of the large station proposed near the present location of the South Ferry, a circular elevated construction could be devised with the necessary easy grade to reach the bridge abutments and allowing the elevated, subway and surface lines to enter the circular ascending grade at their respective levels.

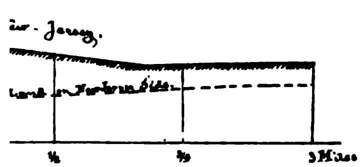
The large surplus of about $100 000 000 would enable the City to construct at once a new rapid transit elevated railway in one continuous belt-shaped line along the East and North River frontages, taking in two local lines up, and two local lines downtown, and the same number of express lines; the fare could be two tickets for a nickel. Besides this benefit for traffic, all lines for freight at outshore side, with hoisting arrangements and sidings at piers could take all freight for railways, steamships, etc., and a more reasonable and quicker express service than the present slow methods could be establisht.

Many more advantages would arise for the City and the public, which we cannot grasp today, and I can only say that I shall be pleased if this work and these ideas help the progress of our great City.

PLATE 52.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
RUGE ON SOUTHERLY EXTENSION
OF NEW YORK CITY.







H. Arnold Ruge C.E.
New York 1893.

DISCUSSION.

MR. GEORGE S. RICE.—There is one gentleman here, Mr. Henschel, who has been acquainted with Mr. Ruge's schemes and plans and I would like to hear a few words from him, if he will be kind enough to talk to us a little while.

MR. ALBERT E. HENSCHEL.—I will accept your kind invitation, Mr. Chairman and Gentlemen of the Society.

The only thing that I might say of moment, is that I might contribute my testimony to give credit to the real author of the scheme that the United States Government has, in part, adopted by the southerly extension of Governor's Iland, and that I innocently played a little part in communicating Mr. Ruge's scheme to the Government. It happened by mere chance, as I might call it. I happened to go down to see Col. Roberts of the Harbor Line Board, who then presided over that United States Department in the Army Bilding, with reference to securing an extension of the plan whereby the pier head line on the New Jersey side was to be extended into the Hudson River about 200 ft. I was interested in the matter which made it desirable that this plan of the Government (which was to go opposite Bull's Head Ferry, or about Thirteenth Street), might be continued further up as far as Fifty-ninth Street. Being interested in another very large scheme, the New York and New Jersey Bridge, which has its charter to bild at Fifty-ninth Street, I thought if I could save the bridge that I represented 200 ft. of construction by getting the Government to run that 200 ft. all the way to a point opposit our bridge, it would be a desirable thing. When I talked to Col. Roberts—I was thru with my particular mission, which, I may mention, I had accomplisht—I said, "By the way, I know of a scheme which my friend, Mr. Arnold Ruge, has, which was publisht not long ago, with reference to Governor's Iland, and its extension, practically uniting Governor's Iland to Manhattan and also extending it southerly." Col. Roberts was very much interested. He had not heard about it and I told him that I would secure him a copy of the New York *Times* or the other paper which had publisht the matter. After he had discusst it with some other official his comment upon it was that the projection southerly of Governor's Iland would be a very desirable thing, but that he thought the union of Governor's Iland with Manhattan would probably make the East River current too rapid for safe navigation. That was his offhand opinion upon the subject. I reported that objection to Mr. Ruge and I think he said at the time that that was a matter to be considered, but that he did not believe that a current would be created to be an obstacle to the plan.

He thought that it would not be a practical hindrance. So there is very much in this lecture of Mr. Ruge's that I approve. I think it is feasible; I think it ought to be done, but it requires public opinion. It requires the molding of the sentiment of the general government to his view, that they might give up something that they have in the way of parading soldiers. Of course, we all know that for purposes of fortification, Governor's Iland affords very little protection to our City, and I am very glad to have the opportunity of saying that Mr. Ruge was the man who is responsible for that part of the plan which has been adopted by the Government, and I do not know that any particular credit has been given to him thus far. Of course, he can show by these papers and slides that these dates precede the plan and the making of that southerly extension. I am also glad to have contributed, as a living witness, to give him credit for that very important valuable work.

MR. GEORGE S. RICE.—Mr. Ruge's plan is getting a little nearer to the Boro of Richmond. Is there any gentleman living down that way, or in Brooklyn, who would like to speak on this subject?

MR. A. SCHREINER.—I would like to ask Mr. Ruge a question. Supposing Governor's Iland extended in a southerly direction and, as shown on Mr. Ruge's plan, piers are bilt all along the new shore line pointing toward the Hudson or East River. Those piers should be able to accommodate all the important steamships that come into New York Harbor. We have steamers now over 700 ft. long and I suppose that new piers will have to be bilt in the future at least 825 or 850 ft. long. Now if you bild piers along the southerly extension over 800 ft. into the Hudson River and over 800 ft. into the East River, would not the extension of these piers into these two rivers affect the currents to a very appreciable extent? As conditions are at present it is very difficult to get those large steamers up to their piers; it takes some time and an enormous amount of power. The *Lusitania* and *Mauretania* require from ten to twelve tugboats to bring them up to their piers. As by the southerly extension of Governor's Iland the velocity of the currents would be appreciably changed, I would like to know from Mr. Ruge if this encroachment would not make the landing of such big steamers impossible?

MR. H. A. RUGE.—In regard to the question of flow, which the Government authorities thought might be too rapid, I would say that if the new bridge had a little larger span than the present Brooklyn Bridge, the water which today can flow thru the Brooklyn Bridge will also be able to flow thru the new bridge. If a vessel can pass under the Brooklyn Bridge today, it can also pass under the new bridge. The velocity will not be increast at the new bridge any more than it is at the old Brooklyn Bridge today. The water

around Governor's Iland has nothing to do with the velocity at the present Brooklyn Bridge.

In regard to the piers, it is true that 900-ft. piers could not be bilt there. That is too great a length for those places. Valuable short piers could be bilt, and the *Lusitania* could land in the same way as the Government proposes to have its great warships land, *i. e.*, in a line parallel to the shore.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 37.

PRESENTED DECEMBER 18, 1907.

THE DESIGNING, MAKING AND TESTING OF A TELESCOPE.

BY MR. F. KOLLMORGEN.*

WITH DISCUSSION BY
GEORGE S. RICE, HERMAN K. ENDEMANN AND THE AUTHOR.

In selecting the subject for tonight's paper, I was guided by the consideration that probably all of you, in the routine of your work, have had to employ telescopes at quite frequent occasions. I do not, of course, refer to astronomical telescopes, the use of which, so far, is confined to the professional astronomer or to the well-to-do amateur. I presume you will be chiefly interested in those attacht to surveying instruments of all kinds, and it is to those principally that I intend to confine myself tonight. They may be only small and insignificant compared to the giants used in astronomical work, but their importance, nevertheless, is not to be underrated, for the best made transit or level is seriously handicapped by an inferior telescope and much valuable time and work are lost thru bad definition, inexact centering of the lenses or thru other optical defects. It is thus of the highest importance that every care should be taken to make the telescope as perfect as possible and thus to render the often very arduous task of the man behind the instrument as easy and his results as reliable as possible.

Before I explain the methods employed in designing the optical parts of a telescope I shall have to state some of the elementary laws of optics, which determin the course of the light rays thru an optical system. The first of these is the primary law of all geometrical

* Optical expert for the Keuffel & Esser Co.

optics:—When a ray of light passes from one medium into another of different optical density, the following phenomena take place at the dividing surface: part of the light is reflected back into the first medium and the other part undergoes refraction, *i. e.*, it continues into the second medium but changes its direction, except in the case of perpendicular incidence upon the dividing surface. Plate 53, Fig. 1, will show this. Here we have a ray of light in the medium M_1 coming from A. It meets the surface which divides medium M_1 from medium M_2 at B, and while part of it is reflected back into medium M_1 to A_1 under an angle equal to that of incidence, we note that the other part goes into medium M_2 in the direction of C. Now, this ray has changed its direction; while in medium M_1 it impinges upon the boundary of the media under the angle of ABN, or a_1 with the normal to the boundary, it now, after refraction, forms the angle CBN_2 or a_2 with that normal. The relation between these two angles is exprest in the simple formula:

$$n_1 \,.\, \sin.\, a_1 = n_2 \,.\, \sin.\, a_2.$$

where n_1 and n_2 are constants particular to each medium, varying only with the color of the light ray. This simple law found by Snellius in 1626 constitutes the foundation of geometrical optics. The constant n is easily determined for every substance by means of a spectroscope, and knowing that, we can, by comparativly simple trigonometrical formulæ, trace a light ray thru any number of optical media.

Plate 53, Fig. 2, shows the course of a light ray thru a triangular prism of glass, ABC. Here the ray impinges upon the first surface, A-B, under an angle a_1 to the normal and after refraction forms with the same normal the angle a_2; the relation between these being given by Snellius's law:

$$n_1 \,.\, \sin.\, a_1 = n_2 \,.\, \sin.\, a_2.$$

Now n, the constant of refraction, generally called the refractiv index, is 1 for air, and about 1.5 for glass, therefore we have in the case of the prism: $\sin.\, a_1 = 1.5 \sin.\, a_2$. The angle a_2 is thus smaller than a_1, or, in other words, the ray deviates toward the normal in the denser medium glass. At the other side of the prism the ray forms the angle a_3 with the normal before, and the angle a_4 after refraction. The same relation of the sines holds good, and we see that again the angle in air, a_4, must be greater than the one in

glass, in other words, the ray deviates away from the normal on entering the lighter medium. It follows, therefore, that light passing thru a glass prism in air is deflected toward the base of the prism. Next we will take the case of a double convex glass lens, as shown on Plate 53, Fig. 3. It is easy to see that we can consider such a lens as consisting of an infinit number of very small prisms of constantly increasing angle, the basis of which is parallel to the so-called optical axis, *A-A*, the line which passes thru the centers of curvature of the two lens surfaces. Each of these partial prisms has a slightly greater angle than the preceding one, as we go from the center of the lens toward the edge, and will, therefore, cause a little more deviation. If we now have a cylinder of light rays falling parallel to one another and to the optical *axis* upon such a lens we can easily see that they will all be so deflected as to intersect the optical axis. We will assume that they will all cut the axis at the same point *F* (tho this is correct only for rays very near the axis). This point is called the focal point or focus, and here an image of the luminous point from which the light rays originated will be formed. In the same way a cylinder of parallel light rays falling upon the lens at an inclination to the optical axis *A-F* will be converged into a luminous point off the axis, and the greater the inclination of the light cylinder to the axis the greater will be the distance of the corresponding focal point from the axial focal point. Thus, to every point of the object which sends light upon the lens, there corresponds a luminous focal point, and the aggregation of these luminous points we call the image. It is easy to see that a point of the object lying above the optical axis will have its image point below the axis, and vice versa, an object point below the optical axis has an image point above. Thus we see that a convex lens (or collectiv lens, as it is also called) gives an inverted image. We can clearly see this image with the naked eye if we bring our eye into the direction of the light—about 10 in. or more behind the focus. We can also catch the image, as you all know, right in the focus on a sheet of paper or a ground glass screen, or a fotografic plate, as is done in fotografic cameras, or else can look at the image thru an ordinary magnifying lens, to enlarge it. This is just what we do in looking thru a telescope: we have a lens of rather a long focus, called an objectiv because it is turned toward the

PLATE 53.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
KOLLMORGEN ON DESIGNING,
MAKING AND TESTING OF A
TELESCOPE.

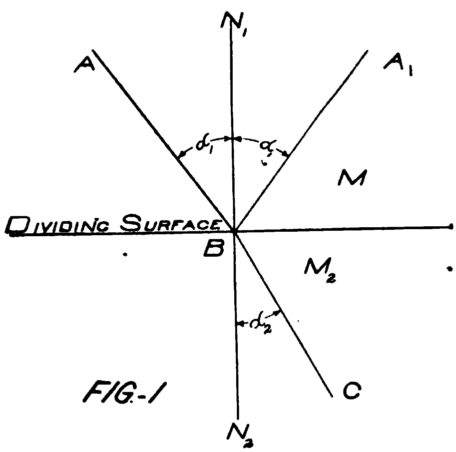


FIG.-1

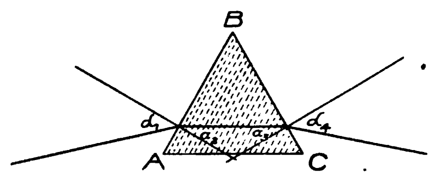


FIG-2

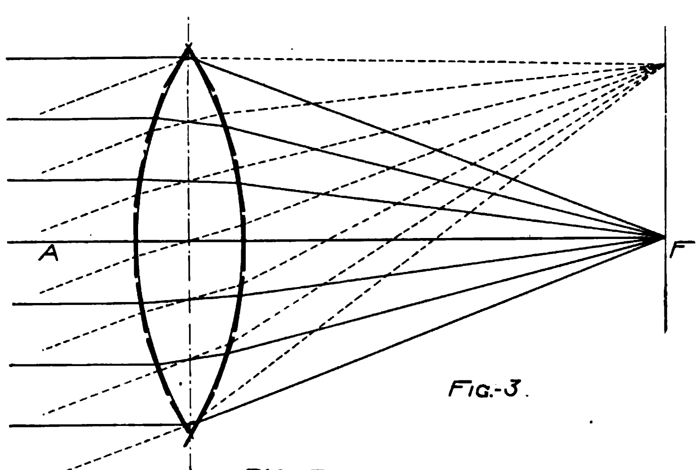


FIG-3

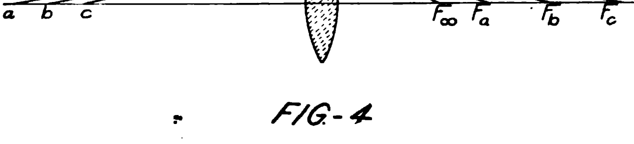


FIG-4

object, at one end of a tube. This lens gives us an image of the object at its focal point, and we look at that by means of a magnifier called eyepiece, as being nearest the eye.

We have assumed, so far, that the light struck our lens from an infinitly large distance and was refracted by the lens toward a point which we call the focal point, the lens acting as a series of prisms, or prismatic rings. Each of these small prismatic rings gives the light rays a certain amount of deviation and as the light rays falling on the rays have been parallel to the optical axis, the total deviation given by each prism lies on the side on which the focal point lies, on the right side as shown in Plate 53, Fig. 4. But if we have a luminous point lying at a nearer distance to the lens, the deviation which each prismatic ring of the lens will give to the light falling on it is partly used up in making the incident light ray parallel to the axis, so that it can refract the rays only by a lesser degree than before and the focal point will therefore lie further away from the lens. Thus: an object lying at a nearer distance to the lens will have a focal point further away from it. Of course, you must understand that this illustration of the prismatic effect of the lens which I have given you is merely an illustration and does not represent the exact course of the light rays, but shows you approximately the action of a lens.

An object point and the point at which a lens forms its image are called conjugate points, or conjugate foci of that lens.

In a concave lens, as shown in Plate 54, Fig. 1, the prismatic action is directed outward, and the rays diverge as if they came from the point *F*, which is called the focus. The rays do not actually form an image there, as they do in the focus of a collectiv lens; they only emerge from the lens in such directions as if they came from an image at *F*; hence we can neither use such a lens as objectiv for a telescope nor catch an image on a screen. We can, however, use such a lens, a negativ or dispersiv lens, as it is called, as eyepiece for a telescope, and it is used as such in opera and field glasses. Such a telescope is called a Galilean telescope, but as it is rarely used for exact work I will not stop to discuss it at present.

The simplest telescope would be, therefore, one which consists of a simple collectiv lens of long focus as an objectiv, and another

collectiv lens of shorter focus as eyepiece. This would be perfectly satisfactory if the assumption that all parallel rays falling on a lens are united in one focus were correct. This, however, is not by any means the case, owing to a number of so-called aberrations. First and foremost among these is color—or chromatic aberration. As I explained before, the index of refraction, n, for each optical medium varies with the color of the light ray. It is greater for those colors which have the shortest wave length, those at the purple end of the solar spectrum, and smaller for the green, yellow and red rays, which have the greater wave length. Now in our primary law of refraction $n_1 \sin. a_1 = n_2 \sin. a_2$, if the first medium be air with the index of refraction $n_1 = 1$, we have $\sin. a_1 = n_2 \sin. a_2$, or $\sin. a_2 = \frac{\sin. a_1}{n_2}$, which shows that the light rays will deviate the more from their original direction the greater the corresponding n in the glass. Ordinary daylight, as you know, contains all the colors of the spectrum; and therefore, if a narrow beam of such light be thrown on a prism, it will be refracted in such a way that its component colors become separated as shown in Plate 54, Fig. 2. Purple and dark blue light, having in each glass the highest n, will be refracted most; light blue and green come next, then yellow, orange and red. In short, we have a regular succession of rainbow colors, or a spectrum. The same thing happens in the case of a lens: instead of having one single image at one single focal point, we have a series of different colored images all lying close behind one another, the purple nearest and the red image furthest from the lens. The result of this great number of many colored images, if we look through a telescope the objectiv of which is a single lens, is very pretty, every object having a beautiful fringe of rainbow colors around it, but, of course, all detail and definition are entirely lost, so that such an instrument would be practically useless. Luckily the optician has the means of correcting this chromatic aberration. There are two classes of glass, the so-called Crown glasses and Flint glasses. The dispersion, that is, the difference between the refractiv indices for different colors, is very much less in the Crown glasses than in the Flints. By combining a negativ Flint lens with a positiv Crown lens it is possible to construct an objectiv free from color aberration. Plate 54, Fig. 3, shows us how that is done. At the top we have a

PLATE 54.
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OF THE CITY OF NEW YORK.
KOLLMORGEN ON DESIGNING,
MAKING AND TESTING OF A
TELESCOPE.

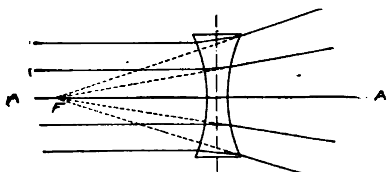

FIG-1

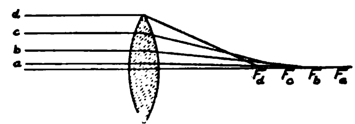

FIG-6

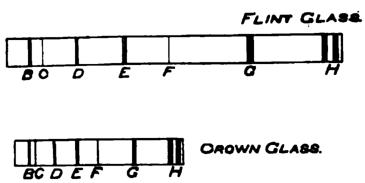

FIG-4

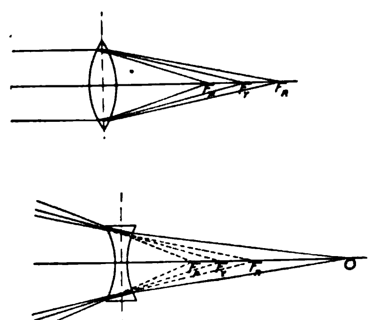

FIG-3

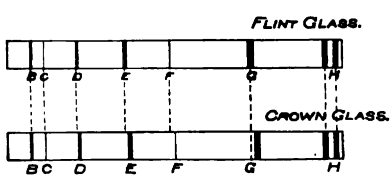

FIG-5

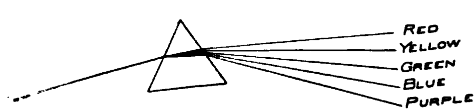

FIG-2

Crown lens, a beam of light falling on it parallel to the axis. It is refracted, and the points F_p, F_y *and* F_r show, on a very much exaggerated scale, the focal points belonging to the purple, yellow and red rays respectivly. Underneath we have a diagram of a negativ Flint lens. As we have seen before, the image of a negativ lens is formed on the same side of the lens as the object; therefore, if we have a white object at O, the lens will refract the light coming from O to F_p for the purple rays, to F_y for the yellow ones and to F_r for the red ones. Now our fundamental law of refraction n_1 sin. $a_1 = n_2$ sin. a_2 shows that we can reverse the course of the light rays, for the formula remains the same if we exchange the indices 1 and 2. Thus we can say: If F_p is the image point (also called the conjugate point) of O for purple rays, then, also, O would be the image or conjugate point of F_p for purple rays, or, in other words, purple rays coming from the point F_p will be refracted thru the lens to the point O. In the same way as F_y is the image point of O by the yellow rays, O will be the image of F_y, or yellow rays coming from F_y will be refracted to O, and likewise red rays coming from F_r will be refracted to O. Now, all we have to do is to construct a Flint lens so that the distances between F_p, F_y and F_r are the same as in the Crown lens above and bring this Flint lens into such a position behind the Crown lens that the points F_p, F_y and F_r of the two lenses coincide. Then, of the white light falling on the Crown lens, the purple rays will be refracted by the Crown lens to F_p, but from there by the Flint lens to O, the yellow rays by the Crown lens to F_y, but thence, by the Flint lens, to O, and the red rays by the Crown lens to F_r and then on to O by the Flint lens. Thus, in O we shall again have an image formed by all the different colored rays at the same spot, and therefore free from all color aberration. A lens combination formed of a Crown and Flint lens so as to give an image free from color aberration is called an achromatic system, or achromatic lens. In every telescope at least the objectiv should be achromatic.

I have here a piece of ordinary Crown glass and two or three kinds of Flint. You will notice that the Flint is considerably heavier than the Crown; the specific gravity of Crown glasses varies between 2.2 and 2.6, altho some very heavy Baryum Crowns much used for high class fotografic lenses run up to 3.6. The Flint glasses

usually have a specific weight from 3 to 5. Here is a piece of extra heavy flint, both its heaviness and its yellow color are due to the great amount of lead oxid which is used to give Flint glasses their high dispersion. The refractiv index for yellow light varies, in Crown glasses, from 1.50 to about 1.61; in Flints, from about 1.53 to 1.78. This yellow piece has a very high index of refraction 1.778, and a dispersion nearly 3 times as great as ordinary Crown. But such extreme glass as this is not suitable for use in telescopes, only in spectroscopes and similar instruments; for telescopic lenses we must choose a glass as transparent and free from color as possible, and for that the medium Flints are the best.

I have shown how we can compensate the color aberration of a Crown lens by a suitably chosen Flint lens, and it seems a very easy and simple method. So it would be, but for one thing. If, in our last diagram, we construct the Flint lens so that its image points F_p and F_r coincide with the points F_p and F_r of the Crown lens, then the points F_y of the two lenses, and quite a number of other colors will not coincide. The reason for this lies in the nature of the glasses; the dispersions of a Crown and a Flint glass are not strictly proportional. Plate 54, Figs. 4 and 5, shows us the spectra obtained by a Flint and a Crown prism of the same angle; the lines B C D, etc., are the so-called Fraunhofer lines of the solar spectrum, B and C in the red, D in the yellow, E in the green, F in the blue, G and H in the purple part of the spectrum. Now, if the dispersions were strictly proportional, then these lines should all coincide if I make the two spectra the same size; but, as you see in the two lower lines, they do not. The Flint disperses the blue end of the spectrum more than the Crown, while the latter disperses the red end more. Thus, in our example with the Crown and Flint lens, if I brought the focal points for purple and red rays, F_p and F_r, into coincidence, the points F_y would not coincide; if F_p and F_y were brought together, the red foci F_r would not be in one place, so that there is always a small remainder of color aberration left. This is called the secondary spectrum of a telescope, and the designer must choose the colors which are to coincide very carefully so that this secondary spectrum may be least harmful. The choice of the right pair of colors to correct for chromatic aberration is one of the most difficult tasks of the designing optician, as it varies with every different pair

of glasses, with the relation of clear aperture to focal length of the objectiv, and as the color aberration complicates itself with the next aberration we have to consider the so-called spherical aberration. This arises from the following cause: we have assumed that the small prisms into which we imagined our biconvex lens divided, all bent the light rays so that they intersected the optical axis at one point. But they do not, unfortunately for the designer of optical instruments; those parts toward the edge of the lens cut the axis nearer the lens than the others, and so, again, we have a series of images behind one another, instead of all in one focus. You can see that in Plate 54, Fig. 6, which shows light rays falling on a lens at a distance of $\frac{1}{3}$, $\frac{2}{3}$ and $\frac{3}{3}$ of its radius of aperture (*b, c, d*), and one near the optical axis (*a*) the rays from the edge intersect the axis a much shorter distance than the others (the drawing, of course, is very much exaggerated). The tendency of this spherical aberration is to impair the definition of the image, even right on the optical axis. I mention this particularly, because a great many people who use telescopes or microscopes mix this aberration up with another entirely different one, the curvature of the image. See Plate 55, Fig. 1. If they find that the definition at the center of the field of view is perfect, but that the edge is indistinct and they have to focus further in to get that clear, they will refer to this as spherical aberration, while it is curvature of the image. In fact, this phenomenon would in most cases prove that there is no spherical aberration in the instrument. For it is a mathematical fact, that in telescopes the objectivs of which consist of two lenses, if the best definition in the center is obtained, then the image must always be curved toward the objectiv. Now, the better your definition at the center of the field, the more easily even the slightest falling off of definition at the edge will be noticed, while in a glass with a little spherical aberration the field will appear more uniform all over, but there is really no sharp, critical definition anywhere. This remark, however, refers only to telescopes with low magnification and a large field, for with magnification over 30, and a field of only about 45 or 50 min. of arc the curvature of the field is not very noticeable.

Now we come to the construction of the eyepiece. As I explained before, the image of the objectiv is inverted. We can now

simply look at this thru an ordinary magnifier and will, of course, thus see the image inverted, and for many purposes, particularly in astronomical and microscopic work, this does not interfere with the work. Plate 55, Fig. 2, shows the most usual types of inverting eyepieces. For many purposes of the surveyor and for the ordinary observation of objects an inverting telescope would not be suitable, and we, therefore, have to erect the image given by the objectiv. This can be done in various ways: a very neat way is that by means of so-called erecting prisms, as you see in the ordinary prismatic binoculars, which of late years have been introduced, but in surveying telescopes this method does not recommend itself, on account of the difficulty of keeping the prisms in adjustment. We therefore have to do this erecting of the image by means of another lens system, which from the primary image forms another image again inverted and this latter image is looked at by the eyepiece. Now, the primary image given by the objectiv being inverted and this being re-inverted by the erector system, we have an erect image to look at with the eyepiece.

Plate 55, Fig. 3, will show how this is done. The points F_1 and F_2 show the place where the two images are formed, F_1 being the first inverted and F_2 the second, erected image. For convenience of construction this image F_2 is placed between the two lenses of the eyepieces proper in Fig. 3a, but that is not by any means essential. By this arrangement we obtain in the simplest manner a perfectly achromatic field.

The principal aberrations in an eyepiece are those of color aberration and distortion. In an eyepiece consisting of 4 single lenses, such as the one shown in Fig. 3a, we can only correct for the color at the edge of the field. There must always be a certain amount of color aberration on the axis (this is a most important point) and this color aberration we have to allow for in the objectiv, if we want to obtain a first-class image. Many instrument makers neglect this important precaution, with the result that the image given by the telescope is gray and devoid of contrast. The objectiv must have aberrations counter-balancing those of the eyepiece, if the best result is to be obtained. For this reason we cannot get satisfactory results with an objectiv which has been designed for an astronomical or inverting eyepiece, if we use this objectiv with an ordinary erecting

PLATE 55.
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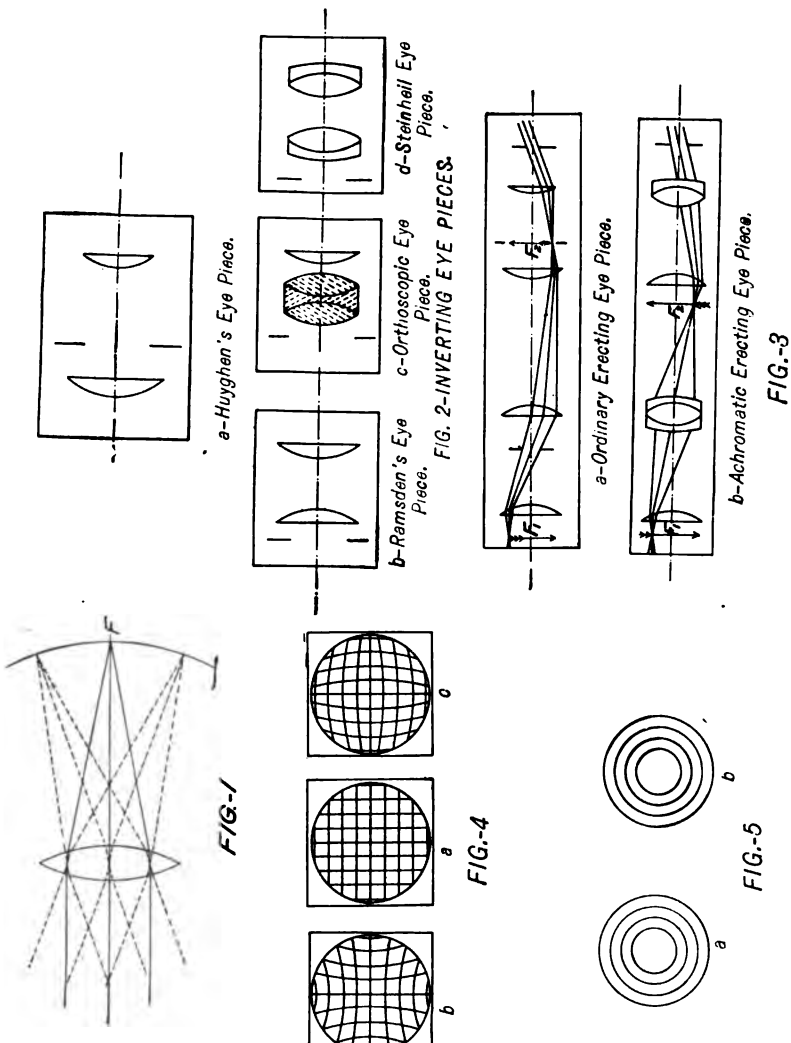
TELESCOPE.



eyepiece. If we want to do this, we have to achromatize the erecting eyepiece by making one or two of these lenses achromatic in themselves, as is shown in our next illustration, Fig. 3b.

The error of distortion, which is likewise very detrimental to the performance of an eyepiece, shows itself in the following manner: If we have a network of straight lines, such as shown in Plate 55, Fig. 4a, the telescope should show us an image absolutely similar to the object. If there is any distortion in the eyepiece, we shall see such a network, either cushion-shaped or barrel-shaped, as shown in Figures 4b and 4c. This is due to the fact that the magnification of the eyepiece is not the same thruout the field, the outer part of the field being magnified more than at the axis in the first case and less in the second.

To sum up, the mathematical part of the telescope designer's work has to attend to the following points: first, determin the respectiv focal lengths of objectiv and eyepiece, then correct the objectiv for color and spherical aberration both inside and outside the optical axis, taking care, in the case of an achromatic erecting eyepiece, to compensate all its errors in the objectiv; then design the eyepiece, so that it gives a field free from colors at the edge and entirely free of all distortion.

We now come to a part of the design which might be described as mechanical. It seems absurd to say that the barrel of the telescope must be designed so that all the light coming from the objectiv shall actually reach the eye of the observer, and yet this is one of the points against which the designers of telescopes for surveying instruments sin more than against almost any other. In many an instrument I have seen large objectivs, say of 1½ in. dia., put onto a tube, the inside dimensions of which would barely measure 1 in., and it is perfectly obvious to anybody that the outer part of the objectiv cannot possibly send any light toward the eyepiece, as it is immediately cut off by the brass cell or the narrow tube behind it.

Plate 56, Fig. 1, shows you a correctly designed instrument in which you will see that the rays falling on the utmost edge of the objectiv go straight thru to the edge of the field without any interference. This is the way that every telescope should be designed, and you should refuse any telescope in which this is not the case, such as is shown in Plate 56, Fig. 2, as you are only

carrying unnecessary weight. Another mechanical point to be considered in a telescope, I would mention: absolutely perfect adjustment of all lenses, so that the optical axes of all lenses lie in one straight line. If this is not the case, the image is affected with an irregular aberration called astigmatism, which I will show you when we discuss the testing of the telescopes. The designer should also see that the eyepiece has sufficient movement to enable the observer to focus on near objects, as this is of great importance in surveying instruments.

We now come to the actual grinding of the lenses. Most of our glass comes from France in rough slabs. This glass is cut into suitably sized pieces by means of a diamond saw, a rapidly revolving disc studded with very small diamonds at the edge. It is then roughed out with iron or brass tools, and ground to the exact curve with carborundum or rough emery. After the roughing process, it is what we call fine-ground with very fine emery and is then ready for polishing. Polishing is done by means of pitch, which is heated and given the exact spherical shape, by means of brass tools. Large lenses are polisht by themselves, but when we have small ones to do, we cement several of them on to one chuck, and they are polisht simultaneously. The polishing is not finisht until the lenses are absolutely transparent and show not the slightest touch of grayness, even when viewed with a strong magnifier. After the polishing, the lenses are centered, *i. e.,* the edges are ground off to the exact size, care being taken that the thickest part in convex lenses and the thinnest in concave lenses are exactly in the center. That means, that the optical axis passes thru the center of the lenses. This is a most important operation. After that, the objectiv lenses and any achromatic eye lenses are cemented together, if required, by means of Canada balsam, at a temperature of 110 to 120 degrees, and carefully adjusted toward each other by means of a spirit level, to bring the optical axes in co-incidence. The lenses are then mounted in their respectiv cells at the correct distance from one another and the telescope is ready.

All of these operations have, of course, to be most carefully checkt all the time, and every lens is constantly tested during manufacture. The first thing we have to test is the quality of the glass and its optical characteristics. The glass may be badly annealed and uneven in

PLATE 56.
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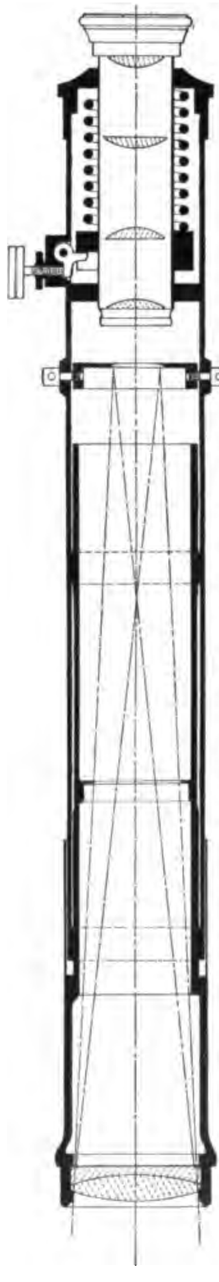

FIG. 1 - CORRECT DESIGN OF TELESCOPE HEAD.

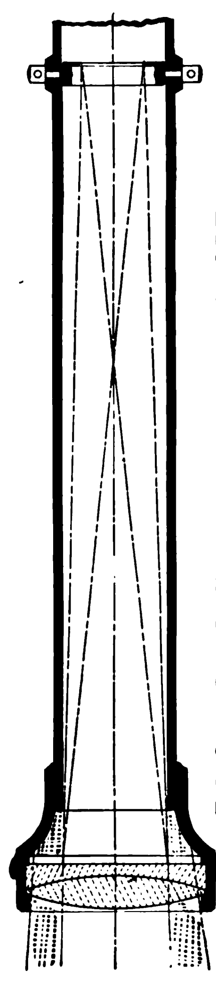

FIG 2- INCORRECT DESIGN OF TELESCOPE HEAD.

The dotted parts show light passing thru the objectiv, but cut off by the brass cell, thus greatly restricting the effectiv aperture of the telescope.

structure, and it is, of course, utterly out of the question to make a satisfactory lens out of such glass. We test this by examining the block of glass by means of a polariscope. If I put into the polariscope a piece of glass, which I have intentionally strained by heating and suddenly cooling it in cold water, you will see, if you examin it thru the instrument, irregular dark and light markings, which indicate bad strains inside the glass. Next, we have to satisfy ourselves about the optical qualities of the glass, *i. e.*, its index of refraction and dispersion. To that end we cut a prism of approximately 60° angle and examin it under the spectroscope. We measure in that the angle of minimum refraction for several lines of the solar spectrum, the best suitable for the purpose being those called *C* and *F* of the hydrogen spectrum and the so-called *D* line of sodium light. This latter we obtain by holding a little salt in the flame of a Bunsen burner, the hydrogen lines by observing the spectrum of the electric discharge thru a glass tube filled with hydrogen, as you see here. From our observations we can easily determin the refractiv index of the glass for these three parts of the spectrum, and any others we may require can be observed in a similar manner.

During manufacture, the first thing to which we have to pay particular attention is to get our curves correct. For that purpose we use a spherometer. We have rings of certain well determined dimensions and in the center a little point, which is deprest, if we put a convex lens onto the ring, or rises in the case of a concave lens. The amount of its depression or elevation can be read by means of a microscope and scale to the $\frac{1}{1000}$ part of a millimeter, so you see that we can get our curve with the greatest exactness. Next, we have to control the shape of our polisht surfaces, for these must be absolutely truly spherical. For that purpose, we make for each lens a so-called test surface, the principle of which is as follows: You may have noticed that a thin layer of oil floating on water will break up into most beautiful rainbow colors. These arise from so-called interference of light in the extremely thin coat of oil, which has a different refractiv index from the water. In the same way an extremely thin layer of air will give a beautiful color phenomenon between two sheets of glass. This phenomenon is known as "Newton's rings." They only show when the two glass surfaces

have very nearly like curvature. Thus we can see them in the case of an absolutely plane surface and one which is very nearly plane, if the two are brought into close contact. In the same way they will show if two curved surfaces, one hollow and one convex, are put in contact with one another, and the wider apart the rings appear the nearer alike the two curves will be. We have in this a most delicate method of testing, for the very slightest deviation of the two curves from one another, even $\frac{1}{400000}$ of an inch, will immediately show itself by means of these colorings. No lenses are past by the foreman and sent out of the optical department until they have past this color test.

The centering of the lenses is likewise tested very carefully. In grinding off the edge of the lenses, the workman observes the reflections which the front and back surface of the lens give of some clearly defined object some distance away. The lens, being fastened on the chuck of a very accurate lathe, revolves rapidly and the two images will only then appear to be perfectly stationary if the two optical axes coincide absolutely. The workman moves the lens about on the pitch by which it is held to the chuck until this result is obtained, then allows his pitch to harden and grinds the lens off to its correct size.

We now come to the testing of the finisht instrument. When a new type of objectiv is constructed, I usually test it by means of a very delicate fotografic method, devised by Prof. Hartmann, of the Potsdam Observatory. A description of this method would be too long for the present paper, especially as, to the practist observer, there are many methods by which he can tell right away whether the telescope has been satisfactorily executed. To test for chromatic aberration, some black-and-white image with very strong contrast, such as the dial of a watch, is observed in a very bright light. If the image is at all gray and does not show vivid contrasts, the fault is usually with the color aberration. A well-designed and well-made telescope should show the image just as full of contrast as can be, with the black parts having a very faint dark bluish-purple edge around them, which is due to the uncorrected secondary spectrum, as I have already explained. Then an artificial star, obtained by letting the sunlight fall upon a small silvered glass ball some distance away, is observed. If the eyepiece be

moved the very least bit inside of its proper focus, this artificial star ought to appear a very pronounct claret color, and in the same way if it be moved the least bit outside of its proper focus, the star should be a rich apple green color. If we have these two color effects, we can be quite certain that the chromatic aberration of the objectiv has been properly corrected. Now, for spherical aberration, we have a very good test in the way the objectiv focuses. There should be only one point at which the maximum of clear definition is obtained. The very slightest movement of the eyepiece either inside or outside of this focus should give an inferior image. Every telescope in which the eyepiece can be moved quite a measurable distance while the image appears equally distinct all the time should be rejected right away as being probably affected with spherical aberration. The artificial star will give us a very sensitiv test for this, at least with all instruments of fairly high magnification. If we move the eyepiece inside or outside of the focus, we should see the star break up into a series of very delicate concentric rings. These rings should be a little more pronounct in the inside of the focus than on the outside, but they must nevertheless be distinctly visible when we go outside of the focus. The test for distortion in the eyepiece is very easy, for, as I explained before, we have only to look at a grating of horizontal and vertical lines, and we can detect immediately if there is any distortion in the instrument or not. The exact mounting of all the lenses in a telescope we can test by looking at a series of concentric rings. (See Plate 55, Fig. 5a.) They must appear of perfectly even blackness and crisp definition all round; if they appear blacker in one azimuth and if this azimuth appears to shift while we focus inside and outside of the proper focal point, the instrument shows astigmatism, which is a sure indication that one of the lenses is not in proper alignment. (See Plate 55, Fig. 5b.)

In regard to the mechanical defects of the instrument, we can easily test whether any light of the objectiv is cut off by faulty construction of the tube. Outside of the eyepiece when the instrument is in focus, you will notice that we can see a small circle of light, which is called the exit pupil of the instrument. We can catch this circle on a piece of paper and measure its dimensions. Now, if we look at this circle from a considerable distance and put our finger

across the objectiv, we can see the image of our finger projecting on this circle. If we gradually withdraw the finger toward the edge of the objectiv, its image will correspondingly disappear from the little bright circle, but it should remain visible until our finger tip reaches exactly the edge of the clear aperture of the objectiv. If it disappears before that, we know that there is some diafram or other obstruction in the telescope which cuts out light and the construction is therefore defectiv.

Another point which is of great importance is the position of the cross-hairs. These should be exactly in the focus of the objectiv, for otherwise we obtain the defect which is known as parallax. The theoretical aspect of this is very simple. The objectiv forms its image at the focal point and the eyepiece in magnifying it throws this image apparently into the distance of distinct vision of the observer—say about 10 in. from the eye, toward the objectiv. Now this point where the image is thrown by the eyepiece and the focal point of the objectiv are conjugate foci for the eyepiece. If the cross wires are not exactly at the same point where the image of the objectiv is formed, they will be projected by the eyepiece to a different distance from the same. They will therefore not appear to lie in the same plane as the image seen by the eye from the eyepiece, and will either seem to lie in front of the image or behind it. In either case, the image of the object and the cross wires will be displaced towards each other when we move our eye in front of the eyepiece, and this is a serious defect, because it renders the exactness of the sighting dependent upon the position of the eye, which it should not be. It is obvious that this defect will disappear when the cross wires are carefully adjusted exactly in the focus of the objectiv, because then they will be projected together with the image into the distance of clear vision, and will appear in the same plane. In some instruments, however, it is not possible to effect this adjustment, and such an instrument is certain to be very defectiv optically, because the impossibility of adjusting the cross wires proves that there is no single focal point to the objectiv. Such an objectiv is obviously quite unfit for use in any surveying instrument.

There are just one or two points more, which I wish to mention, as I know that nearly all of you will be interested in them.

The first is the relativ advantages of the terrestrial and astronomical eyepiece. At first sight, it would appear obvious that a terrestrial eyepiece is more convenient, but this is entirely a question of habit. The eye accommodates itself to seeing things upside down and the hands to using the slow motion screws in the opposit direction so easily that any observer could easily overcome these apparent disadvantages of the inverting eyepiece in a couple of days. Still you do see things upright, and to many people that is a certain advantage, but that is all the advantage that the erecting eyepiece has; in all other respects it is disadvantageous. First, it is considerably longer than the astronomical eyepiece, and, therefore, as the length of the transit or level telescope is limited, we have to shorten the focus of the objectiv correspondingly, and an objectiv with a short focus has always inferior definition to one of a longer focus of the same aperture. For stadia work particularly the short focus of the objectiv is a drawback, as the wires have to be put more closely together and are magnified more by the eyepiece. Then, again, the terrestrial eyepiece consists of a greater number of lenses than the astronomical one and at every surface of each lens there is a certain amount of loss of light by reflection, and not only that, but some of this reflected light is reflected back again from some other lens surface towards the eyepiece, and all of this doubly reflected light casts a faint veil of stray light over the whole image, which renders the latter considerably less brilliant. In the inverting eyepiece which, as you saw, consists of fewer lenses, there is hardly any such stray light and loss by reflection, as I said before, the eyepiece, especially the ordinary four-lens erecting eyepiece, is full of aberrations of its own, for which we have to compensate in the objectiv, but this compensation is not possible in all respects. There always remain several aberrations which are only partially compensated, and we therefore cannot get such a perfect image with an ordinary erecting eyepiece as we can with an astronomical eyepiece. Of course, with the complicated 7 or 8-lens achromatic erecting eyepiece, we can correct all these aberrations, but the great number of lenses in this construction makes errors by defectiv centering in the eyepiece much more probable than in the simpler forms. From all points of view, therefore, except that of convenience in seeing things right side up, the astronomical inverting eyepiece is

very much to be preferred, especially as it also allows of a larger field of view.

The other point I wish you to bear in mind is that of bubbles in the glass. Many an engineer complains about one or several small bubbles in the objectiv of his instrument, but the only effect they have is to take out an absolutely infinitesimal amount of light. You can easily compute the damage done by any bubble for yourselves. You have only to calculate the area covered by the bubble, or blowhole, as they are also called, and subtract it from the total area of the objectiv. You will find that it takes quite a number of bubbles of ordinary size to cover an area equal to $\frac{1}{10}$ of one per cent. of the clear aperture of the lens. You must also remember that a bubble in the objectiv cannot be seen by the eyepiece, for the eyepiece, as I explained before, is nothing but a magnifier, and therefore can only show things that are in the immediate neighborhood of its focal point. Now the cross wires are at the focal point of the eyepiece, but the objectiv is a long way removed from it. We must also bear in mind that the best optical glass cannot possibly be produced free from blow holes. While it is quite easy to produce ordinary window glass free from them, it would obviously be absurd for the optician to make the freedom from such minor defects his principal consideration. The first thing to aim at is a first-rate image with as large a field as possible, with good definition all over, and you cannot obtain that with ordinary window glass. In fact, the heavy crown glasses which are best suitable for obtaining a flat field with high grade definition show the greatest number of small bubbles. I have a few samples here in which you can see these bubbles in great numbers, and I will just tell you that this glass costs nearly four times as much as ordinary crown glass, so you see we must have pretty forceful reasons for employing this glass. In high grade fotografic lenses this glass is absolutely essential, and all well-known makers have in their catalog a paragraf explaining the impossibility of obtaining this glass free from bubbles, and stating that they will not exchange any objectiv merely on account of bubbles. It is different, however, if a bubble is found in one of the eyepiece lenses. There it may be near the focal point or too near the eye and appear in the field of view as a more or less indistinct spot. In this case, of course, it is objectionable and the lens having

this bubble has to be exchanged; that happens quite frequently. In connection with this matter of bubbles, I will mention the small star-like spots that appear in the objectiv when the cement cracks. This does happen occasionally when the instrument has been exposed to great extremes of temperature, and while, of course, these small markings can easily be done away with by recementing the objectiv, they are of no importance whatever, as regards the definition. Therefore, when the engineer discovers these spots in his instrument, there is no need for him to pack the whole instrument up and send it back to the maker for repair, spending a few dollars on expressage and being obliged to lay his work aside till the instrument comes back. He can continue working it for many months without noticing any bad effects. If anything does go wrong, however, with the optics of your instrument, you must bear in mind that the ordinary optician selling spectacles, opera glasses, barometers and so on, is almost the last person in the world to whom a telescope should be given for repairs, for these men are frequently entirely ignorant of telescope optics, and will sometimes spoil an instrument beyond all hope of repair. I have recently had a case of a telescope which some such optician had had to repair. He had very carefully cemented the two objectiv lenses together, but unfortunately they were of a type not made to be cemented, but having entirely different curves at the surface where crown and flint lenses join. The result of his cementing was, of course, perfectly fatal to good definition.

These remarks exhaust the subject of my paper. I have, of course, had to give you only a very cursory synopsis of all the points I mentioned. The subject is one of considerably more interest, as everything else, if you go deeper into it, and I trust my remarks have not been too tedious for you.

I shall be very glad to give any further information that any of you might wish to have, and have brought these instrument along with me, to show you, if you wish it, how we make our tests.

DISCUSSION.

MR. GEORGE S. RICE.—I am sure you gentlemen are very much interested in this subject. He has explained it very fully. I could follow it in its entirety and I know you gentlemen have been able to do so.

There is one question I would like to ask Mr. Kollmorgen. You spoke about using balsam at 110° temperature in putting the lenses together. Do we not find that out on the work we sometimes have a temperature of more than 110°, with the sun shining on the lenses?

MR. F. KOLLMORGEN.—Yes, certainly, the balsam softens when the temperature rises over 110-115°, but a displacement of the lenses thereby is impossible, for they are fitted very closely into their cells and besides held down tight by the ring screwed into the back of the mount, so that when the balsam hardens again the lenses are joined together in exactly the same position. A softening of the balsam is therefore entirely harmless, unless the lenses fit too loosely in the cell, in which case they may get displaced towards each other and produce astigmatism in the image. It is, of course, possible to use a cement which softens at a higher temperature, but we have found it advisable not to go any higher, because cement with a higher softening point contracts and hardens too much in cooling and thus sets up strains in the lenses, which entirely destroy all definition. On the other hand, it is possible to use a soft balsam which never hardens, and keep the lenses in position simply by the screw ring; or one could even use a construction like this objectiv here, in which the two contact curves touch only at the edges and the lenses are entirely uncemented. Such objectivs are used for spy-glasses by the U. S. Navy and by the English Army, but for surveying instruments they are less suitable than cemented objectivs, on account of the greater difficulty in keeping the axis of collimation true.

MR. HERMAN K. ENDEMANN.—I would like to ask a question. I have noticed in some of our instruments used in Queens Boro, and it may be a common fault, that if we focus upon an object and set the telescope so that the image of the object we are observing falls upon the intersection of the cross-hairs, and then move the object glass so that the object will be a little out of focus, the image will move from the intersection of the cross-hairs. In this a defect in the construction of the telescope that can be avoided by the maker? When the focus in an instrument correctly constructed is altered, should the image disappear at the intersection of the cross-hairs?

MR. F. KOLLMORGEN.—This phenomenon is a very frequent one and may be due to a mechanical or to an optical defect. It is obviously a mechanical defect, if the draw tube carrying the objectiv does not slide strictly parallel to the optical axis. In this case, the mechanical and the optical axis of the tube are inclined to one another and intersect at the focal point where the cross wires are placed. Moving the draw out either way will cause the image to slide off the cross wires. On the other hand, this may be caused by an optical imperfection, usually by the fact that the two objectiv lenses have become deranged during or after cementing. There will then be astigmatism in the image, such as I have shown you before, on the concentric rings. The effect of this astigmatism may be sufficiently strong to throw the "center of gravity" of the light sideways, thus your image would appear to move sideways the moment you get out of its focus. If you examin an instrument by means of those concentric rings that shows the appearance that Mr. Endemann has described, you will soon see whether the lateral movement of the image is caused by astigmatism of the lens or a faulty draw tube.

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.

ADDRESS OF MR. GEORGE S. RICE, PRESIDENT OF THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK, PRESENTED AT THE ANNUAL MEETING OF THE SOCIETY, JANUARY 22, 1908.

As provided in the By-Laws of this Society I present an address embodying in general the progress of work carried on by the municipality of New York and the work done by the Society during the year ending December 31, 1907.

From the reports submitted by the Board of Directors, Secretary, Treasurer and the several Committees, it is apparent that our Society is in a prosperous and sound condition, of which we all can be proud, and which proves that the Society has supplied a much-felt necessity.

In successfully carrying out the objects of this Society we have demonstrated that a material benefit has been derived by the City in whose interests we are employed, by elevating the standard of efficiency in the various engineering departments, making it possible for these departments to cooperate with one another, and at the same time promote the technical, professional and social interests of the men themselves.

The meetings of the Society were largely attended, the average attendance being 140; the maximum 215 and the minimum 103.

A number of interesting trips were made to work in progress in different parts of the City, which were well attended, and which also served to add to the engineering knowledge and the promotion of good fellowship among the members and those who are allied with us in carrying out large public enterprises.

It is my belief that no other city in the world has such a staff to carry out the almost endless variety of engineering problems which the necessities of the City of New York present, involving an

expenditure of many tens of millions of dollars annually. In this Society will be found experts on almost every subject to be considered.

Annual Dinner.

At our Fifth Annual Banquet held on the seventh of this month, you were all no dout pleased with the recognition by most of the speakers of the services rendered by the Engineer to the City, when it was predicted that the Engineer of the future would be better appreciated by the public at large, and that the men belonging to this Society, being technically equipt and having a better knowledge of the different subjects, would have more voice in the consideration of public affairs.

The Dinner was a great success, 336 persons being in attendance, and all departed well pleased with this, the social affair of the year.

Membership.

The increase in membership of the Society has been very encouraging, as can be readily realized in that the number of members on January 1, 1906, was 366, on January 1, 1907, 426, and on January 1, 1908, 509. Today 32 new members have been added, so that our membership is still increasing, and allowing for natural losses, the number will soon, I hope, reach the 600 mark.

Our Society supplies a want not filled by any other organization, and while its good work is not fully known and capable of estimation at the present time, its membership extends to all of the departments where work of an engineering nature is done.

Finances.

The finances of the Society are in excellent condition. On the 1st of January, 1908, we had $868.85 on deposit in the bank, and a municipal bond valued at $2 000. The property of the Society contained at its headquarters, including the Library, represents quite an expenditure of money, which is bound to increase with the growth of the Society.

On January 1, 1908, the cash balance was $868.85 with liabilities of $1 047.33. During the year current receipts amounted to $4 655.94 and the disbursements were $4 243.24.

Permanent Quarters.

The most important move made by the Society during the year was the securing of permanent quarters in the Engineering Societies' Bilding at No. 29 West Thirty-ninth Street. The preliminary steps were taken in the year 1906, and since the occupancy of the new quarters, the advisability of such a change has been demonstrated. Altho the change of quarters has increast the expenditures, the fact of being located in this magnificent bilding, with the privileges and conveniences which are at the command of the Society, is a considerable asset, and has no dout been the means of increasing the membership, and has contributed to the success of the Society in general. No matter how large our meetings may become we can always have at our disposal sufficiently large rooms to meet our requirements.

BOARD OF WATER SUPPLY.

The work now being carried on by the City, and that which is under contemplation, is of great magnitude. The principal work started during the year was that of securing additional water supply to that now in use.

In the Reservoir Department land surveys for the entire reservoir site, excepting the section toward the westerly end, have been completed. The acquisition of eleven sections of real estate, representing about 10 000 acres, has been approved by the Board of Estimate and Apportionment, and title has vested in the City for nine of these sections, representing about 8 000 acres. Nine commissions of appraisal are now at work in Ulster County.

All the detailed investigations necessary for the preparation of contract drawings and specifications for the dams of the Ashokan reservoir have been completed, designs have been made, and the contract for the construction of these dams, which will comprize the largest single piece of work in the entire project, was awarded on August 26. The contractors are now on the ground and proceding with the work.

An entirely practical route for relocation of that portion of the Ulster and Delaware Railroad which lies on the reservoir site has definitly been determined and will soon be reported to the Board of Estimate and Apportionment.

As opportunity permitted, some preliminary work has been done on the Rondout and Schoharie water-sheds to more definitly determin the locations of dams, and topographic surveys have been made so that more detailed information may be available.

The work of the Northern Aqueduct Department extends from the Olive Bridge dam to Hunter's Brook, or the Croton water-shed, 62 miles.

The entire location of this length of aqueduct, including both the siphons and the grade tunnels, has been definitly determined, and the following work has been done in connection with these studies:

Miles of line surveyed....................	344
Acres of farms surveyed..................	10 817
Miles of borings, sounding and test pits......	18.7

Investigations in the Hudson River have progrest favorably, and they indicate that a deep tunnel is the probable method by which the river will be crost. Two shafts at the proposed crossing are now over 350 ft. in depth; the rock is sound and scarcely any water reaches the shafts. All indications are favorable for this work and that a tunnel may be easily driven under the river and no large amount of water would enter it.

A contract for about 11 miles of aqueduct between Cold Spring and Hunter's Brook was let on March 27, and the work has progrest favorably thruout the season. Altho no condit has been constructed, the work is so far advanced that the actual bilding of the aqueduct will begin as soon as the weather permits in the spring.

Land maps for property necessary for 41 miles of aqueduct have been approved by the Board of Estimate and Apportionment. Commissioners of appraisal have been appointed for 92 parcels.

The two most difficult pieces of work in this department are the Rondout and Wallkill siphons, which are each about 4½ miles long. Investigations are now complete, and the preparation of the contracts are in an advanced stage, so that they can be soon advertised.

The work of the Southern Aqueduct Department extends from Hunter's Brook, on the north, to Hill View reservoir, on the south, a distance of about 25 miles, and includes Kensico reservoir and the filtration plant.

The general location of the aqueduct has been determined for the entire distance, and all surveys and investigations necessary for the preparation of the specifications and contract drawings for Kensico dam have been completed, and this contract for the dam is practically ready for advertising.

Diligent search has been made for the most favorable filtration site, and it has finally been fixt at East View. The maps for the condemnation of this property are now being prepared.

Six sections of real estate maps, comprising 455 acres, have been prepared and title has vested in the City. These comprize the property for the Hill View and Kensico reservoirs. Additional maps for aqueduct taking are in progress.

Extensiv investigations have been made of the supply of water which could be obtained from Suffolk County in Long Iland, and a comprehensiv scheme for the development of these sources has been prepared.

A very large amount of work has been done by the Engineering Department in making designs, contract drawings and specifications for the various contracts which have been let and which are to be let in the future. Twenty million dollars worth of work is practically ready for contract, and specifications have been written and the investigations and studies have progrest to a point where contracts for all the work necessary for the delivery of water to the Croton watershed can be prepared and advertised during the coming year.

Work on contracts aggregating over $18 000 000 is now in progress, and nearly 1 000 men are employed on this engineering work.

AQUEDUCT COMMISSION.

At the New Croton Dam the flashboard equipment was completed, and in November last the reservoir was filled and the water commenced to flow over the first course of flashboards, since which time it has continued to run to waste in varying quantities. The amount of water now in storage in the various reservoirs on the Croton Watershed is approximately 80 000 million gal.—more than eight months' supply at the present rate of consumption, an amount in excess of that at any previous time and which probably will not be seen again for many years.

The Cross River Reservoir has been practically completed. As is generally known to Engineers, this dam is constructed of cyclopean masonry, with a facing, both upstream and downstream, of concrete blocks. The foundation is upon solid rock, which was excavated until a satisfactory quality was found. The upper portion of the dam is reinforced by a system of steel rods running the entire length of the dam. The overfall is at the northerly end of the dam and is also bilt on a rock foundation, the wasteway leading from the spillway being excavated into natural rock. Concrete blocks for the facing were made in the immediate vicinity of the dam. After trying various methods, they were cast in molds, the side forming the face being lined with metal. They were cast face downward. The total amount of cyclopean masonry was 132 500 cu. yd., and the total amount of facing blocks was 17 600 cu. yd. The dam is 986.5 ft. long, including the core wall, and the spillway is 240 ft. in length. The extreme hight of the structure from the foundation to the roadway across the top is 170 ft. The greatest thickness is 116 ft. The capacity of the reservoir is slightly in excess of 10 000 million gal. The area of the water surface when full is 900 acres. This work was completed practically within the time limit fixt in the contract, and, had it not been for an injunction by the Court early in the work, it would probably have been completed considerably within the contract time. Water is now being stored behind this dam.

The Croton Falls Reservoir is well under way. Excavation for the main dam, amounting to 230 000 cu. yd., is practically completed and the rock foundation exposed. The water of the West Branch of the Croton River, on which this dam is being constructed, has been diverted thru a temporary flume. The diverting dam on the East Branch is also well under way. Many miles of highways have been constructed and are now in use. The main dam will be bilt of cyclopean masonry with concrete facing blocks similar to the Cross River Dam. The diverting dam on the East Branch is to be an earth dam with a masonry core wall. This work is now and will be during the coming season in a very interesting state of progress.

No work has been done at the Jerome Park Reservoir this season, pending a decision on the question of filtration.

DEPARTMENT OF DOCKS AND FERRIES.

The work of constructing the bulkhead or sea wall at various sections of Manhattan by this Department has been in progress during the year.

The work in the Chelsea Sections, with the exception of the construction of sheds, is now practically completed for the entire length of the section—Gansevoort to West Twenty-third Streets, and the work of grading, curbing and paving the marginal street is almost completed. The construction of passenger and freight sheds on two of the piers and adjoining bulkheads has been commenced. The contracts for sheds for the other piers in this section have been awarded. The work between Beekman Street and South Ferry has been completed under the new plan and South Street widened.

The Long Iland Railroad Company abandoned the operation of its ferry service between James Slip and Long Iland City on May 11, 1907, and since that time the Department has been engaged in removing the old structures and carrying on work in accordance with the new plan.

The work of bilding a bulkhead wall between Twenty-sixth and Twenty-ninth Streets, East River, about 980 ft. in length, including the return on the northerly side of East Twenty-ninth Street for Bellevue and Allied Hospitals, is progressing. The Department is also engaged in the construction of a sea wall at the easterly side of North Brother Iland in order to enlarge the Iland. The retaining structure bilt by the Department around the easterly end of Riker's Iland was completed during the year, thereby forming a basin of over 150 acres in extent for the use of the Department of Street Cleaning.

Work on the slips and terminals of the Municipal Ferries has been in progress during the year. The terminal at St. George is practically finisht and the bilding opened for use of the public. At Stapleton the work of bilding a ferry slip and pier to be used in connection with the operation of the ferry, has been completed. At the New York end of the ferry to South Brooklyn, near the foot of Whitehall Street, work is now in progress under contract for the erection of ferry structures and a temporary waiting room has been bilt which is now in use, together with one of the new ferry slips. At the Brooklyn end of this ferry the work of bilding ferry slips,

etc., is in progress. Plans and forms of contracts have been prepared for the ferry house to be erected at Stapleton, Staten Iland, foot of Whitehall Street, Manhattan, for the Staten Iland Ferry and at Thirty-ninth Street, South Brooklyn.

The receipts of the Staten Iland Ferry from passenger and vehicular traffic for the year ending November 1, 1906, the first year of municipal operation, showed an increase over the last year of private ownership of $98 382.67, or about 20%. The receipts for the year ending November 1, 1907, show an increase over the previous year (first year of municipal operation) of $53 305.08, or about 9%. The City commenced the operation of the ferry to Thirty-ninth Street, South Brooklyn, on November 1, 1906. The receipts for the year ending November 1, 1907, show an increase of $24 155.55, or about 15%. Three ferryboats, the *Gowanus, Nassau* and *Bay Ridge,* bilt by the Harlan & Hollingsworth Company for service on the ferry to Thirty-ninth Street, South Brooklyn, were completed during the year, at a cost of $640 000. These boats are now in commission.

The following statistics show the length of wall bilt, wharfage room made, etc., during the year:

Total length of bulkhead wall bilt................	1 674 lin. ft.
Total length of wharfage room made, including construction of bulkhead wall................	17 787 " "
Increase in superficial area of City's piers, including ferries	383 898 sq. ft.
Number of piers bilt, including extensions........	6

DEPARTMENT OF BRIDGES.

Various construction is under way to further facilitate traffic on the Brooklyn Bridge. The completion of the temporary extension of the Manhattan terminal across Park Row will shortly be effected. This extension will provide temporary facilities for elevated railway traffic during the reconstruction of the main station, and will permit the operation of six-car instead of five-car elevated trains during the rush hours, thus allowing the operation of thru elevated trains during the entire day and doing away with the necessity of passengers transferring at the Brooklyn station during the morning and evening rush hours.

The capacity of the Brooklyn Bridge in connection with the elevated railroad and surface trolley traffic has been maintained up to its maximum of uniform train and car operation under improved schedules. The passenger traffic over the bridge railways on two corresponding days of the last two years, shows an increase of over 5% in the year 1907.

Spacing signals have been placed across the bridge on the surface car tracks, causing not only improvement in the operation of the surface cars, but affording better facilities for team traffic, and thereby lessening the hindrances and delays due to blockading of trolley tracks by vehicular traffic.

That thru passengers may have the maximum service on the bridge elevated trains, arrangements have been made to take the local traffic on surface cars crossing the bridge, and work is now in progress on the construction of the necessary loop thru the ground floor of the Brooklyn station, which will permit the removal of the local service from the elevated to the surface tracks. A new line of surface cars will be operated exclusivly for this local traffic from one terminal of the bridge to the other.

One obstacle to the speedy operation of surface cars over the bridge has been the congestion existing at the entrance and exit to the bridge at Sands Street, Brooklyn. To remedy this congestion construction is now under way of a steel viaduct which will allow all surface cars entering or leaving the bridge to pass over Sands Street along the outside of the Brooklyn station and separating the car traffic without grade crossings. This improvement will add very materially to the surface car capacity of the bridge.

To permit the maximum operation of elevated trains over the bridge, an efficient system of block signals is being installed. In anticipation of the connection of the bridge railroad with the subway loop to the Williamsburg Bridge, which is now under construction, various matters are in progress with a view to the construction of a new station in Manhattan which will provide for the adequate necessities of all classes of traffic. The roadways on the Manhattan approach are being widened in connection with this improvement.

The work of constructing a subway station at the Manhattan end of the Williamsburg Bridge is drawing to a close. The trolley car service over the bridge has been increast about 7% over last year.

Work on several contracts to provide for the operation of elevated trains across the bridge, and to provide a suitable station for surface cars at the Manhattan end, is progressing.

This work has involved not only the construction of the subway station before mentioned, but also the alteration of the Manhattan steel viaduct and masonry approach and the construction of an elevated railway connection on the Brooklyn Plaza, which is practically finisht.

A shelter house for the accommodation of people in inclement weather has been constructed on the Plaza.

On the Manhattan Bridge the Brooklyn anchorage has reacht that stage of construction where it is ready for the steel superstructure. The Manhattan anchorage is nearing this stage. The steel towers on both sides of the river have been erected to a hight of about 70 ft. Bids were opened for the Manhattan and Brooklyn approaches on December 9.

The construction of the steel superstructure over Blackwell's Iland and the East River is rapidly nearing completion, and it is expected that the spans will meet early in the spring. Contracts have been let for the construction of the approaches on the Queens and Manhattan sides, and this work is being vigorously pusht.

The design for the proposed Henry Hudson Memorial Bridge has been prepared and submitted to the Art Commission for its approval. A large amount of work has been done in connection with this design preparatory to the making of complete detail drawings. These plans provide for a masonry arch nearly two and one-half times larger than any masonry arch heretofore constructed, and also provide for a future four-track subway connection across the river.

The construction of the University Hights Bridge is completed and opened for traffic.

The contract for the construction of the new Madison Avenue Bridge has been let, and a temporary bridge, to provide for traffic during the construction of the new bridge, is completed and ready for the removal of the present draw span to its temporary location.

The construction of the new bridge over Pelham Bay Narrows has progrest so that the structure is now ready for the erection of the steel required for the movable span.

The bridge across Dutch Kills at Borden Avenue, in the Boro of Queens, is under construction.

RAPID TRANSIT AND PUBLIC SERVICE COMMISSIONS.

During the year 1907 the Board of Rapid Transit Railroad Commissioners, by an Act of the Legislature, was succeeded by the Public Service Commission for the First District which assumed the powers of their predecessors, together with various other duties.

The rapid transit railroad in Manhattan, called Contract No. 1, is practically complete, the final estimate having been rendered on November 30 last. The road as originally designed as to its length is in running order, and all permanent stations are in use with the exception of the two at the upper end of the east and west side branches, where temporary stations have been bilt and have been in use for some time.

An extension to the road on the west side to Van Cortlandt Park has been under construction from Two Hundred and Thirtieth Street to Van Cortlandt Park. The foundations for this structure are in place, and a good part of the elevated structure. The work on this extension was suspended later in the year owing to street relocations, which necessitated changes in the stations, and the work was also delayed on account of slow deliveries of steel. This work, however, will be completed about the middle of this year.

The traffic on the rapid transit railroad has increast in the last year over that of 1906 by about 22%, or 182 559 900 pay passengers during the year, which makes an average daily travel of 500 000 passengers and has now increast to 600 000 passengers per day by the opening of the tunnel to Brooklyn two weeks ago. The maximum number of pay passengers for one day in December was 687 000.

The extension to Brooklyn, Contract No. 2, is now under construction. From the Post Office in Manhattan to the Boro Hall in Brooklyn the road is in operation, including, of course, the tunnel under the East River. By May of this year the remaining portion of this Contract No. 2 will be in operation to the Long Iland Station at the junction of Fourth Avenue and Flatbush Avenue. It is probable that within a year the rapid transit railroad covered by these two contracts will have at times a daily travel of over 700 000 passengers.

Last spring plans were prepared and contracts drawn for north and south tubes on Manhattan Iland, designated as the Lexington

Avenue Route and the Seventh and Eighth Avenue Route, including a route up Jerome Avenue. These two routes were advertised for public letting, but no bids were received.

A subway connecting the Manhattan terminals of the Brooklyn, the Williamsburg, and the Manhattan Bridge (now being constructed) was authorized, and was subdivided into five sections and called the Brooklyn Loop Lines. This work involves an expenditure of over $10 000 000, and it is expected that it will be completed in two or three years.

In the latter part of last June the Rapid Transit Board authorized the preparation of plans and specifications for a subway route connecting with the easterly end of the Manhattan Bridge and running to Fort Hamilton by the way of Fourth Avenue in Brooklyn, and with a connection to Coney Iland. These plans are now being prepared, and within the next few months contracts, involving the sum of more than $15 000 000, will be advertised for public letting.

The ventilation system on Contract No. 1 has been installed and is in successful operation from the Brooklyn Bridge station to the tunnel at One Hundred and Fifty-seventh Street, the heat during the summer months having been materially reduced in that part which had been relieved with openings.

On Contract No. 2, being the extension of the subway to Brooklyn, provision has been made for ventilating the East River tunnels and the portions of the subway now being constructed in Brooklyn.

For ventilating these two tubes, two shafts are now being constructed, one in Battery Park, Manhattan, and the other in Joralemon Street, Brooklyn. These shafts are about 5 500 ft. apart. In a chamber at the top of each shaft two motor-driven blowers of 46 500 cu. ft. of air per min. capacity are being installed. The air is to be delivered thru flues to nozzles located at both sides of each tunnel section. Normally the air will be discharged into the tunnels behind and in the direction of the moving trains. Dampers will be provided in the flues at both ends of the tunnels, and so arranged that the direction of the air can be reversed should emergency require it.

Altho the general public realize the need of better facilities in

the matter of transit both on, above and below the surface of the streets, the following statistics are given relating to the population and traffic in New York City, as a whole and by boros. Considering all the boros groupt into one great population center, it appears that during the four years ending June 30, 1905, the total number of paid passengers traveling on all street railways—surface, elevated and subway roads—increast practically in a straight line, that is, the increment in each succeeding year was about the same. During 1906, however, there was a sudden markt increase in the traffic. While the average increment for the four preceding years was only about 63 000 000 per year, during 1906 it amounted to nearly 110 000 000. No census of the population of the Greater City was made in 1906. It is therefore impossible to determin whether this large additional number of riders is due to a corresponding increase in the population, or to an increase in the number of rides per capita, but an increase in the population is the most probable cause, as will appear later. The growth of the travel in the boros separately has not always been parallel with that in the whole city, as was notably the case during the last three years. During 1902 and 1903, the increases were practically uniform in each boro; the amount of increase in each boro being greater in the order of the size of population of the boros—that is, the increase was smallest in Richmond and largest in Manhattan.

During 1904 and 1905, with the travel in the whole city still increasing at a uniform rate, there was a loss in the rate of increase in the travel in Manhattan, and a corresponding gain in all the other boros, but mainly in Brooklyn. This may be accounted for by a temporary movement of some of Manhattan's population to the other boros. The only reason that can be ascribed for this migration was the interference with travel in Manhattan due to the bilding of the subway.

In 1906, when the notable increase in the number of paid passengers in the whole city occurred, there was a general increase in the rate of travel in all the boros. This was a greater rate than had prevailed during any of the preceding years which have been considered. Manhattan recovered more than was lost during the years 1904 and 1905. All the other boros made material gains.

In the upper portions of Manhattan, a territory which was not

conveniently accessible before the subway was opened, a great many apartment bildings have been erected and there has been a large movement into this district.

It would appear, therefore, as already stated above, that the pronounced growth in 1906, in the total number of paid passengers traveling in the whole city, can only be accounted for by a corresponding increase in the city's population. This is probably due to the operation of the city's first subway, a great many suburban people having been induced to come into the city in view of the increast facilities afforded. It is now proposed to take up each boro, more or less in detail, and finally to make some speculations with regard to the transportation requirements within the next decade.

In the Boro of Richmond 15 571 889 paid passengers were carried during the fiscal year of 1906; 8 957 414 of these were carried on the surface lines, the remaining 6 614 475 on the steam roads; the daily average was nearly 43 000. During the last five fiscal years the number of passengers carried increast at a fairly uniform rate. The total increase for the five-year period was about 28%. This boro now has on an average about two inhabitants to the acre. It is estimated that its population may be about 100 000 in 1916, or a little less than three to the acre. Approximately 60% of all the passengers in Richmond, about 26 000 per day, are now transported to and from Manhattan by ferry. The increases in population and passengers transported will probably be greater than indicated above. However, assuming that the same rates are maintained, in 1916 there should be approximately 26 000 000 paid passengers carried in Richmond. About 15 000 000 of these will have to be provided with transportation to and from Manhattan. Each inhabitant of the boro now rides 210 times per year; in 1916 he would ride about 260 times. There are now 130 miles of single track operated in Richmond. The transportation problem here can be taken care of for many years to come by the natural expansion of the present systems to develop new territory and an increase in the car mileage to meet the added demands of the growing population.

In the Boro of Queens the conditions are somewhat similar to those in Richmond, except that the population is larger and has increast about twice as fast.

In 1906 the population was 208 596. The completion of the tunnels now under construction will probably cause a phenomenal growth in the population. Based on a normal ratio of growth, however, it is estimated that it will be about 300 000 for 1916. In studying the traffic, the Long Iland Railroad has not been included. There were 22 115 729 paid passengers riding on the surface lines during 1906, an increase of nearly 100% during the five fiscal years, as against the 28% increase in Richmond. The number of rides per inhabitant is smaller in this boro than in any other. In 1901 there were 73 per capita per year; in 1906, 106. If the traffic increases as rapidly during the next decade as it has during the past five years, in 1916 the travel in Queens boro will equal over 88 000-000 paid passengers. To carry this traffic within the boro, as was the case in Richmond, it will only be necessary to increase the car mileage as occasion demands, and to add to the trackage in undevelopt territory. This does not dispose of the passengers whose objectiv point is Manhattan; these must be provided with facilities for crossing the East River.

The statistics are not directly available from which the number of people bound to Manhattan can be determined. It has been estimated, however, that about 60% of the riding passengers both in Richmond and in Brooklyn cross to and from Manhattan each day. Using this same ratio, then about 53 000 000 people, exclusiv of Long Iland Railroad passengers, will have to be transported across the East River from Queens in 1916, either by ferries, bridges or tunnels.

The Blackwell's Iland bridge and six tunnels are now being constructed between Manhattan and Queens. Two of the tunnels enter Manhattan at Forty-second Street and are known as the Belmont tunnels; the other four are the Pennsylvania tunnels thru Thirty-second and Thirty-third Streets. The bridge provides for two elevated and two trolley tracks; in all there will be five tracks in each direction. The Pennsylvania tunnels will probably be used mostly by Long Iland commuters. If these tracks are omitted from consideration, three tracks in each direction will still be available for the use of this boro. These facilities should be in operation within four years. Their combined maximum capacity should be over 133 000 000 per year, with a maximum hourly

capacity of over 73 000 in one direction. If all passengers are to be provided with seats then the above figures would become approximately 60 000 000 and 33 000 respectivly. The residents of Queens will therefore have ample facilities for reaching Manhattan for many years to come.

During the fiscal year of 1906, 389 555 025 paid passengers were carried on the street railways in the Brooklyn boro, a daily average of over 1 067 000. This represented 278 rides per inhabitant for the year.

The elevated lines carried 125 221 831 and the surface lines 264 333 194, or about 32% and 68%, respectivly, of the total number. Over 60%, or approximately 234 000 000, of all of the above passengers were carried to and from Manhattan over the bridges and ferries. There has been a slight increase each successiv year in the rate of increase of the total passengers carried. Considered separately, the riders have increast faster on the elevated than on the surface lines.

The number of surface riders in 1906 was about 27% greater than in 1901. During the same period the amount of single track operated has increast less than 2%, and the car mileage only about 11%. This has resulted in a greatly increast crowding on all lines. For the same five fiscal years the population has grown less than 18%. Each inhabitant has taken 189 rides on the surface cars during 1906, as compared with 174 rides during 1901.

If the same rates of increase which have prevailed during the past five years are maintained for a decade, in 1911 the number of paid passengers carried on the surface roads in Brooklyn will amount to about 336 000 000; in 1916, to about 426 000 000.

These figures do not represent the maximum rates at which passengers will have to be carried during the rush hours. During these hours it is estimated that transportation will have to be provided on the surface lines at the rate of over 100 000 per hour in one direction in 1911, and 140 000 per hour in 1916.

The travel on the elevated railroads in Brooklyn has very nearly doubled, while the surface roads were gaining 27%. To carry this enormous increase of traffic only 9.346 miles of single track have been added, or only 11% more than was operated in 1901. The car mileage during the same period has not increast 60%. It

appears, therefore, that the increase in facilities on the elevated railroads has not kept pace with the growth in the traffic. The whole transportation system, both surface and elevated roads, is greatly overburdened. It is obvious that in order to provide relief for Brooklyn's population the subway systems must be extended into and thru the boro as quickly as possible. When this is done the surface lines will be greatly relieved; they can then be depended upon to fulfil their proper functions, that is, furnish the necessary short-haul service. Long-distance passengers will be provided for on the elevated and subway lines. The capacity of the present surface and elevated lines is about 280 000 000, if moderate crowding is permitted during the rush hours.

From careful estimates it is believed that not far from 560-000 000 paid passengers will have to be provided with transportation in Brooklyn on all lines during 1911, and 800 000 000 during 1916. Deducting the capacity of the present facilities, subways should be bilt by 1911 to accommodate 280 000 000 people, and by 1916, 520 000 000 people.

To furnish this service with only moderate crowding, one four-track railroad operating ten-car trains should be completed across the East River and into Brooklyn within the next five years; and one more within five years afterwards or two altogether during the next decade.

If, however, all passengers are to be provided with seats during the rush hours new subways must be provided for 370 000 000 passengers by 1911, and 610 000 000 by 1916, or two four-track railroads must be constructed to Brooklyn within the next five years, and four within the next decade.

The population of the Bronx boro at the end of the fiscal year 1906 was 288 417. It has grown over 38% during the last five fiscal years. During the same period the number of paid passengers carried on the surface lines, or, it may be said, the travel within the boro, has increast at a uniform rate of more than 36%. The corresponding increase in the passenger car mileage has been less than 27%, consequently the service now provided is not as good as it was five years ago. The trackage is sufficient, and adequate surface car transportation in this boro can be furnisht for some years by increasing the car mileage or number of cars in use.

The elevated and subway traffic in the boro represents the travel to Manhattan. The number of paid passengers using the elevated road increast at a uniform rate up to 1904. The next year there was a very slight increase, due wholly to the opening of the West Farms branch of the subway, which had been in operation for seven months. In 1906 the use of the subway caused a falling off in the number of elevated passengers. Apparently the subway has had no effect upon the travel on the surface lines in The Bronx. Probably about 42 000 000 paid passengers will be carried on the surface lines in 1911, and 57 000 000 in 1916.

Manhattan's population was 2 167 585 for the 1906 fiscal year. This represented an increase of about 15% in five years. The traffic on all the lines in the boro has increast nearly 39% during the same time, but the growth has not been uniform thruout the whole period. The percentage of increase for each succeeding year was less than that for the preceding year up to 1905. For 1906, as already stated, there was a markt increase in the travel on all lines. While in each year the total travel has increast over that of the preceding year, the same thing cannot be said of the surface, elevated and subway lines when considered separately. During 1902 and 1903 there was a steady increase in the number of paid passengers carried on both the surface and elevated roads. In 1904 there was a falling off on the surface lines and a corresponding increase on the elevated lines. This was probably due almost entirely to the interference with the surface cars caused by the construction of the subway. But the surface and elevated lines showed a loss in 1905, which combined was equivalent to the travel on the subway during that year. Most of the subway passengers, however, were drawn from the elevated lines. There were nearly 21 000 000 less passengers using the elevated than in 1904—a loss of 10%, instead of what should have been a gain of nearly 20%, due to the subway travel. During 1906 the surface roads gained a little over the previous year, but the elevated roads continued to lose passengers.

In the fiscal year of 1906 the surface cars in Manhattan carried 391 354 877 paid passengers. This was a total increase of about 7% in five years. It has already been shown that the population of the boro increast 15% during the same period. Each inhabitant rode 194 times during 1901, as compared with 181 times in 1906.

It is therefore apparent that the public are not riding on the surface cars as often as formerly. There are several reasons for this. The subway traverses a section of the city which had not formerly been provided with rapid transit facilities; therefore, those who had been compelled before to use the surface cars immediately changed to the subway. Again, a great many have moved their homes from lower Manhattan into upper Manhattan and The Bronx, and in consequence have become patrons of the elevated and subway roads. The number of passengers carried in 1906 does not represent the maximum number carried per year during the last five years. In 1903 there were 396 570 435 surface car passengers, amounting to nearly 200 rides per capita. This was the summit year of the surface car travel. The changes in the trackage and car mileage have not corresponded with the variations in the traffic. The former has increast about 14%, but the latter only about one-half of 1%. The density of traffic, or number of paid passengers per car mile, has increast over 6%.

At present, if there were greater facilities for the long-distance travel, the traffic on the surface lines would be materially less. The surface lines should be wholly available for the short hauls. If the traffic growth on these lines for the five years just past is maintained for a decade the paid passengers would then be about 419 000 000 in 1911, and 448 000 000 in 1916. This number can probably be taken care of on the present surface lines without excessiv overcrowding, provided the street conditions are so regulated as to reduce to a minimum the obstruction to car movement, and the size of all the cars in service is increast to the dimensions of the largest cars now being used. It would be of great benefit if the movement of vehicles on the car tracks were prohibited, or at least restricted, particularly during the rush hours. Careful investigations made by the Merchants' Association during 1903 will confirm these statements.

It has already been pointed out that a large number of former patrons of the elevated changed to the subway as soon as it was opened. The elevated and subway roads in Manhattan are considered together, since they both provide for the long-distance travel. The combined traffic on the two systems during the fiscal year ending June 30, 1906, was 355 331 924 paid passengers,

227 538 369 riding on the elevated roads, and the remaining 127-793 555 using the subway. In five years the number of long-distance riders has increast over 108%. The number of such riders per inhabitant has been 91 for 1901, and 164 for 1906. The enormous gain indicated above was accompanied by a corresponding loss on the surface lines. It is unlikely that such an increase in the elevated and subway traffic will be maintained for more than a few years at the most; it merely represents a change from one system to another. The more nearly correct conditions will be shown in the increase in traffic on all lines. Moreover, since Manhattan and The Bronx are interconnected by both the elevated and subway lines, it will be desirable to consider these two boros together in arriving at any conclusions relativ to the traffic on these two systems.

The population of Manhattan and The Bronx has been estimated at 2 456 002 for the fiscal year 1906. It will probably be about 2 740 000 in 1911, and 3 170 000 in 1916. The total paid traffic for the last five fiscal years has increast about 41%, to 818 273 413 per year, or an average of about 2 242 000 per day. The number of rides per capita is now about 333. The above total paid passengers are distributed as follows: Surface lines, 422 567 025; Elevated lines, 257 786 756; Subway, 137 919 632. The surface lines carry about 52% of the total traffic, and the elevated and subway lines together the remaining 48%. It appears, therefore, that at present in Manhattan and The Bronx the traffic is about equally divided between the surface roads in one case and the elevated and subway in the other, while in Brooklyn and Queens only about one-third of all passengers were carried on the elevated lines.

At the 41% rate of increase for five-year periods the total traffic in Manhattan and The Bronx will be about 1 153 000 000 in 1911 and 1 626 000 000 in 1916, daily averages of 3 131 000 and 4 454 800. Transportation must be provided for the rush hour conditions, or maximum number carried in one hour in one direction. The capacity of the existing elevated and subway roads, based on such conditions, if all passengers are to have seats, is not far from 200 000 000 per year; if moderate crowding is to be permitted, about 300 000 000. The estimated number of surface car riders has

already been stated—for Manhattan, as 419 000 000 in 1911, and 448 000 000 in 1916; for The Bronx as 42 000 000 in 1911, and 57 000 000 in 1916. Deducting these figures and the estimated capacity of the existing elevated and subway lines from the total estimated traffic to be taken care of in 1911 and 1916, we have either, when seats are furnisht, 492 000 000 and 921 000 000, or, with moderate crowding, 392 000 000 and 821 000 000 passengers, respectivly, for whom transportation must be provided in new subways yet to be constructed.

Under moderate crowding, two additional subways must be completed within five years and four within ten years. If seats are to be provided, three additional four-track subways will have to be put in operation within the next five years, and three more within a decade, in order that the inhabitants of Manhattan and The Bronx may be transported to and from their daily business in comfort and decency.

DEPARTMENT OF WATER SUPPLY, GAS AND ELECTRICITY.

Manhattan.

The regular work of maintenance and constant extension and remodeling of the distribution system has been continued to keep up with the increase in consumption and provide a more efficient supply for domestic and public use, especially for fire protection.

The contract for laying mains for a high-pressure fire system was started in May, 1906, and was completed in December, 1907; there are 54 miles of pipe, ranging from 12-in. to 24-in., and all situated in the crowded section of the city, and having about 1 100 hydrants. Contracts for bildings connected with this work were started in the fall of 1906 and are nearly completed. Contracts for salt water intakes were started in the fall of 1906, and are nearly completed. Contracts for pumps, motors, etc., were started in December, 1905, and the pumps are now being installed. The system was started January 1, 1906, and will be in operation in the spring or summer of 1908. The total cost of the system will be \$3 900 000. It will cover 1 375 acres, from Chambers Street to Twenty-third Street, and from the Hudson River to the Bowery. Plans for future extensions have been made, but are not complete.

Plans and studies have been made for many projects in connection with the protection of the purity of the City's water supplies, among which are the filtration of the waters of Oakland Lake, the disposal of sewage at Mount Kisco and the filtration of the water which comes from the Croton River. Nothing has been done in connection with carrying out the plans, except that in the filtration scheme for the Croton water, an experimental station was bilt and has been in operation during the year.

BROOKLYN.

Extension of Water Supply.—Three new driven well stations were establisht along the condit line and two new driven well stations within the Boro limits.

Extension of Condits.—The new 72-in. steel riveted pipe line from Ridgewood to Valley Stream, L. I., has been completed; the total cost of the work done is $1 065 217. The length of the pipe was 9.2 miles.

Extension of Pumping Capacity at Ridgewood Pumping Station.—Work has been started on the contract for remodeling and extending the old Ridgewood Pumping Station, and on contracts for erecting eight water-tube boilers and four new pumping engines in the remodeled station. The contract prices for this work amount to $678 165.

Extension and Improvement of the Distribution System.—A large amount of work has been done during the year in extending the distribution mains into the outlying sections of the Boro, in replacing the tuberculated mains in older sections with new and larger mains, and in setting fire hydrants and cutting in cross-connections and new gates on the old mains in other sections. The length of pipe laid was 44.3 miles.

High-Pressure Fire Service.—The laying of the high-pressure fire service mains in the water front and dry goods districts of the Boro has been completed. The total cost of the contract was $770 187. The work done covered 22.1 miles. The number of hydrants set was 703.

The Reserve Pumping Station at Willoughby and St. Edwards Streets has been completed and is ready for operation. The Main Pumping Station at Furman and Joralemon Streets is nearly completed.

DEPARTMENT OF PARKS.

Boros of Manhattan and Richmond.

St. Nicholas Park, between One Hundred and Thirtieth and One Hundred and Forty-first Streets, St. Nicholas Avenue and St. Nicholas Terrace.—The work of constructing this park was prosecuted during the year. The section north of One Hundred and Thirty-fifth Street is practically completed, but the section south of One Hundred and Thirty-fifth Street will not be completed until the spring. The plans, forms of contract and specifications for bays, approaches and comfort stations are practically completed.

Colonial Park, between One Hundred and Forty-fifth and One Hundred and Fifty-fifth Streets, Bradhurst and Edgecomb Avenues.—The work of improving this park north of One Hundred and Forty-ninth Street was begun and will be completed early in the year.

Central Park Water Supply.—Two contracts covering an expenditure of $100 000 for instaling a water supply and irrigation system between Fifty-ninth and Seventy-second Streets, and Ninety-seventh and One Hundred and Tenth Streets, were executed and the work has been completed. This system takes the place of the old and ineffectiv sheet line pipes which, thru long service of about fifty years, had become useless.

Entrance to Central Park at Sixty-sixth Street and Central Park West.—The entrance to Central Park at the point mentioned, which has, for some time, been left in a very unfinisht state owing to lack of funds, has been paved, new sidewalks constructed, basins bilt, a new drainage laid, and otherwise generally improved.

Harlem River Driveway.—A new water supply (6-in. pipe) between One Hundred and Seventy-fifth and Dyckman Streets was laid, with the necessary appurtenances, branched, drinking hydrants, road hydrants, street washers, horse troughs, etc. The work is fully completed.

Cathedral Parkway.—Over 10 000 ft. of pipe rail fence, with finials, cresting and wire mesh facing, has been erected to enclose the new tree plots constructed between Fifth Avenue and Riverside Drive.

The work of repairing the asphalt walk pavements in the City Parks was begun, and 200 000 sq. ft. of new pavement has been laid.

Plans and specifications have been prepared for the erection of a new comfort station to cost approximately $30 000, which is to be bilt in the Ramble in Central Park, in the vicinity of the Seventy-ninth Street Transverse Road. Such station is to take the place of the existing bilding which was of the earth closet type. A new sewer had to be constructed to take the sewage from this new bilding thru Seventy-ninth Street transverse road to the City sewer.

Fifth Avenue, between One Hundred and One Hundred and Tenth Streets, was repaved with asphalt wearing surface on a concrete foundation and a new curb was set. The work on the section between Ninetieth and One Hundredth Streets, which is also under contract, could not be begun owing to the lateness of the season.

Tree pits were constructed in Thomas Jefferson, De Witt Clinton and St. Gabriel's Parks and Manhattan Square. These tree pits hold from 10 to 15 cu. yd. of mold. Trees were planted in the same, and were protected by tree guards.

New storage yards, including sheds and other bildings, an incinerator, and a manure pit, were constructed.

Propagating houses were erected at One Hundred and Fourth Street in the vicinity of the greenhouses.

Boro of The Bronx.

A large amount of work was done by this department in The Bronx in the general improvement and maintenance of the parks.

At Pelham Bay Park the Athletes' Lodge on the athletic ground was completed and has been in use for several months and considerable work has been done in draining swamp lands. The work of six-tracking the N. Y., N. H. & H. R. R. thru this park and across the Bronx and Pelham Parkways, has necessitated the approval of plans, and three bridges for overhead crossings and one for deprest crossing have been under construction, the abutments having been completed and part of the approaches.

At Van Cortlandt Park, the comfort station on the easterly side of the parade ground has been finisht; a large amount of work on sidewalks, paths and roads has been done; all the northerly and part of the southerly side of Gun Hill Road has been terraced from the

end of Mosholu Parkway to its junction with Grand Avenue, and a 10-ft. walk constructed from the head of Gun Hill Road to Grand Avenue.

Van Cortlandt Avenue, at the railroad station, has been widened and macadamized for 350 ft. and other incidental work done.

The location and grade of the highway at Van Cortlandt Station has been changed to conform to the underground crossing bilt by the railroad. The new road from Grand Avenue to the Yonkers city line thru the park, was finisht from Mosholu Avenue to beyond Grand Avenue.

At Bronx Park a new music stand has been constructed on the same site as the old stand. A concourse entrance into the Zoological Park from Pelham Avenue has been constructed and work has been pusht in the erection of an elephant house. During the early part of the year the boat house and deer house were completed and have been in use for some months. The southeast entrance gate at Boston Road and One Hundred and Eighty-second Street has been completed and the public comfort station near this entrance is almost finisht. The widening of Boston Road, between One Hundred and Eighty-second Street and the Bronx River Bridge has been finisht. Considerable progress has been made in the development of the different departments of the Botanical Garden; the rubble stone foot-bridge has been bilt on the site of the old Blue Bridge and the river road, extending from the east end of the Long Bridge northerly along the east side of the Bronx River to the Newell Avenue entrance, was finisht and opened for use in November, completing the driveway system in the northeastern part of the grounds. The main driveway at the Lake Bridge is now finisht, thus completing the main north and south driveway thru the western part of the grounds.

At Crotona Park, a substantial wall was bilt around the pond near the lake; the pond was deepened and enlarged and paths constructed. A stone wall was also bilt around the grand-stand and about a mile of paths and walks were constructed.

At Macomb's Dam Park, the N. Y. C. & H. R. R. R. Co. have been filling the bed of Cromwell's Creek, and minor improvements have been made in bilding railing and filling, etc.

At Claremont Park considerable grading has been done on the

Clay Avenue side of the park and walks and sidewalks have been constructed.

At St. Mary's Park a new music stand has been constructed and considerable work done bilding walks, regrading, etc.

At Franz Sigel Park, considerable filling and grading has been done at the southerly end of the park, and the work of remodeling the comfort station has been finisht.

At St. James Park, Echo Park and other small parks, considerable work has been done in grading, terracing and bilding railings, etc.

On the Bronx and Pelham Parkway a large amount of work has been done in putting this parkway in good shape by resurfacing, etc.

At Mosholu Parkway and Spuyten Duyvil Parkway a considerable amount of grading, etc., has been done.

Boro of Brooklyn.

The work of this department has been directed mainly in improving the several parks.

Prospect Park, the principal one of this Boro, naturally received the greatest attention. The forest trees, a prominent feature of this park, have been particularly lookt after and the diseased and dead trees and shrubs have been replaced by new and thriving specimens. The roadways have been renovated and put into good condition; the deterioration of these was caused mainly by the excessiv use of automobile traffic which not only impaired the roadways, but caused a large amount of objectionable dust. The boat house and approach have been finisht and are being used by the public. The swan-boat lake has had its shore line rebilt. The granit steps on the Fifteenth Street side of the park are now completed and in use, as well as the new shelter for men near the main entrance.

At Forest Park the new golf house has been completed and opened for public use.

At Highland Park a new aquatic garden was laid out and planted.

Fort Greene Park, City Park, Carroll Park, Winthrop Park, Cooper, Bushwick Park, Irving Square, Saratoga Park, Lincoln

Terrace, Linton Park, Institute Park, Bedford Park, Tompkins Park, Seaside Park and Bensonhurst Park have all had careful attention, and considerable work has been done on them in the aggregate, so that no depreciation would take place.

At the Parade Ground, which is now devoted mainly to athletic sports, a new bilding has been erected for the accommodation of those interested in outdoor sports, and it has been put in use and greatly appreciated by the public.

At Willink entrance, near the southern end of Prospect Park, grading and sidewalk work has been completed.

At Sunset Park a new shelter house has been erected and other improvements have been made.

At McKinley, Dyker Beach, Fort Hamilton, Amersfort, Fulton, Canarsie and Greenpoint Parks and some of the small parks thruout the Boro, some work has been done, but many of them are in an unfinisht condition at the present time, which naturally does not encourage as much systematic work as if they were complete.

At McLaughlin Park, considerable work has been done in the construction of two playgrounds with running tracks, and these were opened for children's use during the summer.

Ocean Parkway has been so much used for traffic between Brooklyn and Coney Iland that it has required a large amount of surfacing and repairing to keep it in good condition. That part between Prospect and Bay Parks has been coated with Hudson River gravel and rolled, and that between Kings Highway and Coney Iland has been resurfaced with traprock and also rolled.

On Eastern Parkway—the main roadway between Ralph Avenue and Prospect Park has been partly re-covered with gravel and considerable attention was paid to the trees and planting places. On the Eastern Parkway Extension, between Ralph Avenue and Bushwick Avenue, the roadway has been resurfaced in some places where necessary and repaired in other portions.

Pennsylvania, Bushwick, Pitkin and Glenmore Avenues have been repaved and repaired, where necessary, as has also been Bay Parkway.

Fort Hamilton Avenue, which has been constructed as a parkway, has practically become a business street and has been a source of trouble to keep in repair on that account.

That part of Bay Ridge Parkway between First and Fourth Avenues has been kept in good condition by resurfacing.

Boro of Queens.

There are several small parks in the Boro of Queens which have received considerable attention, among which is Kings Park, where new concrete walks have been constructed and some grading done.

Ashmead, Flushing, College Point, Linden and Rainey Parks and Poppenhaüsen Square have all been carefully lookt after and improvements made.

BOARD OF ESTIMATE AND APPORTIONMENT.

The Board of Estimate and Apportionment authorized during 1907 assessable improvements as follows:

Boro.	No. of Improvements.	Cost.
Manhattan	38	$361 000
Brooklyn	269	2 181 800
Bronx	126	3 492 200
Queens	58	644 300
Richmond	30	337 050
Total	521	$7 016 350

The total bond issue for bridge improvements, relief sewers, hospitals, dock improvements, water supply, repaving, rapid transit construction, schools and school sites aggregated about $90 000 000.

TOPOGRAPHICAL BUREAU.

Bronx.

There were initiated 87 procedings during the year by the Board of Estimate and Apportionment for acquiring title to avenues and streets in the Boro of The Bronx, and maps and descriptions were forwarded in 77 cases, damage maps in 45 cases, final "damage" and "benefit" maps in 15 cases, and maps of bildings for sale in streets in 19 cases. The Topographical Bureau during the year prepared a complete system of new house numbers, requiring the sending out of about 15 000 notices. Forty-two maps referring

to the laying out and establishing grades of streets were prepared and placed on file.

Number of contracts in force January 1, 1907	....	87
" " " completed during 1907	....	111
" " " executed during 1907	....	75
" " " in force January, 1908	....	51

Actual cost of contracts completed during 1907, \$1 509 000. Length of streets regulated, graded, etc., during 1907, 16.82 miles, which includes Morris Park Avenue and Broadway, both of which are practically complete.

Brooklyn.

Surveys were completed for preliminary hearings for widening 8 streets; 153 maps for adoption were made of 51 streets; 355 maps for filing for 71 streets; 98 miscellaneous maps of 49 streets; and 20 maps showing encroachments for 10 streets—making a total of 626 maps for 181 streets. Ninety-six rule maps were made for 24 streets; 42 profile maps for damage surveys for 21 streets; 84 draft damage maps for 28 streets, and 42 draft benefit maps for 42 streets.

Queens.

The main features of the topographical maps adopted, are for Jackson Avenue, 150 ft. wide, extending eastward from Blackwell's Iland Bridge; Queens Boulevard, 200 ft. wide, which is to be the main thorofare for Blackwell's Iland Bridge to Jamaica and the Rockaways; Berrian Avenue, 100 ft. wide, a marginal street skirting the East River and Flushing Bay, Jamaica Bay Improvement and Sunny Side Yard.

Richmond.

The work of the Topographical Bureau has been continued, the work done consisting of surveys from the basic triangulation to the completed maps, showing the existing conditions followed by the studies of street systems, parks, boulevards, etc., with preparation of "damage" and "benefit" maps for street openings.

BUREAU OF HIGHWAYS.

There were nearly 78 miles of pavement laid in the City of New York during the year, one-half of which was done in the Boro of Brooklyn, as shown by the following table:

MILES OF PAVEMENTS LAID DURING 1907.

Boro.	Sheet asphalt.	Block asphalt.	Granit.	Bituns concrete.	Wood.	Macadam.	Granit block on sand and asphalt block on concrete.	Iron slag.	Medina.	Belgian.	Brick.	Total.
Manhattan..	3.94	5.68	2.95	....	0.54	....	....	....	....	....	....	13.11
Brooklyn..................	24.28	6.23	3.44	....	....	2.82	....	....	1.38	0.12	....	38.27
Bronx......	1.18	9.88	0.59	....	1.77	....	....	0.25	....	....	....	13.60
Queens.....................	0.94	1.36	... .	....	1.13	....	....	....	....	....	0.92	4.35
Richmond................	....	1.34	0.11	0.60	....	4.59	0.42	0.5	....	....	0.87	8.44
												77.77

BUREAU OF SEWERS.

A large amount of sewer work has been done during the last year, principally in the boros outside of Manhattan, as in that boro almost all the streets have been supplied with sewers.

SEWERS BILT IN 1907.

Manhattan	6.09	miles
Brooklyn	21.41	"
Bronx	14.00	"
Queens	8.44	"
Richmond	5.14	"
Total	55.08	miles

BROOKLYN GRADE CROSSING COMMISSION.

The work of abolishing all grade crossings on the Brighton Beach Railroad to Coney Iland and on the Long Iland Railroad between Bay Ridge and the boro line has been continued.

The Brighton improvement is practically finisht.

On the Manhattan Beach Railroad, grade crossings have been abolisht from Bay Ridge to a point east of Flatbush Avenue, with the exception of the crossings at Coney Iland Avenue and the temporary track across Ocean Avenue. Crossings have been abolisht from Canarsie Road northerly and including Newlots Road.

PENNSYLVANIA R. R. TUNNELS.

Outside of the regular work which is being carried on by the City, there are a few enterprises in progress of construction under the supervision of the City officials, one of which is the Pennsylvania Railroad Company's tunnels which connect New Jersey with Long Iland. The tunnels under the North River have been connected, and the work is now progressing under the East River, and in all probability the four tunnel headings of this portion of the road under the East River will be connected within a few months. The limiting point of this portion of the work, however, will be the finishing of the terminal station on the west side of the City, between Thirty-first and Thirty-third Streets, near Seventh and Eighth Avenues. The tunnel excavation work in Manhattan is practically completed, altho considerable masonry construction is still to be done.

THE HUDSON COMPANIES TUNNELS.

The Morton Street tunnel of the Hudson and Manhattan Company is almost ready for operation to and along a portion of Sixth Avenue in Manhattan. This tunnel connects with New Jersey by two tubes, and will be an important factor of convenience in travel between New Jersey and the eastern and southern portions of Manhattan.

In the lower end of the City, in the vicinity of Dey Street, another of the Hudson and Manhattan Company's tunnels to New Jersey is under construction. The terminal station between Cortlandt and Fulton Streets is well under way, and the tunnel has been bilt almost the entire distance across the North River.

The Belmont tunnel, connecting the Boro of Manhattan from Fourth Avenue and Forty-second Street with Long Iland City, is practically complete, and altho not bilt under the supervision of any City department, the operation thereof is dependent upon the perfecting of the franchise which was granted in the early nineties under certain restrictions and regulations.

NEW YORK CENTRAL & HUDSON RIVER R. R.

Plans for a subway on the west side of Manhattan were prepared in accordance with an Act of the Legislature by the Rapid Transit Railroad Commissioners to accommodate the freight and passenger traffic of the New York Central Railroad from Spuyten Duyvil to St. John's Park. In the early part of the year it was expected that arrangements would be effected by which a portion of this route would be placed underground, but such arrangements were not made, and in accordance with an Act of the Legislature the City authorities were ordered to condemn the property where the railroad past thru city streets. Such proceedings are now being instituted by the City's legal department.

In the foregoing pages it has been your President's endeavor to cover the most important work done by the City of New York, but he realizes that there have been several omissions, some made purposely and others due to the inability to get the information in time for publication.

MEMOIRS OF DECEASED MEMBERS.

CHARLES HAYNES HASWELL.

Charles Haynes Haswell, who was doutless the oldest civil engineer in the world and whose long life was characterized by professional activity and conspicuous public service, died at his residence, No. 324 West 78th Street, New York City, on May 12, 1907. Had he lived ten days longer he would have entered upon his ninety-ninth year.

Mr. Haswell was one of the charter members of the Municipal Engineers, and was always greatly interested in its objects and activities. While his advanced age prevented him from attending the meetings of the Society, the members who were present will always remember the address he gave at our first annual dinner.

Not only did Mr. Haswell's life cover a period of almost marvelous development and progress in this city and country, but he contributed in an extraordinary degree to that development and progress.

Born on May 22, 1809, in a house still standing on North Moore Street, in this city, he received a liberal education in the best schools of New York and Long Iland and then entered the service of James P. Allaire, the owner of the largest steam engine works then in the United States. His experience there gave him a thoro and practical knowledge of mechanical engineering, and his excellent work coming to the attention of the United States Navy Department, he was called upon to design the machinery of the United States steam frigate *Fulton*. He was then commissioned by President Jackson as Chief Engineer to superintend the construction of the engins and boilers of that vessel in accordance with his plans.

The warships *Missouri*, *Mississippi*, *Michigan* and *Alleghany*, and several revenue cutters, were afterward designed by him or bilt under his direction. In 1843 the position of Engineer-in-Chief of the United States Navy was created, and Mr. Haswell was appointed to this important office, which he held for eight years, and his administration of which was characterized by fidelity to the highest professional ideals and a fearless devotion to his duty as he saw it. These estimable qualities were not always appreciated by those

CHARLES HAYNES HASWELL.

with whom he had official relations, and in 1851 he resigned his commission and began private practice in New York City.

While Mr. Haswell was best known in connection with steam and marine engineering, his work covered nearly all branches of civil and mechanical engineering, and he was the author of the engineer's pocket book which bears his name, which has been one of the best known books of its kind and has passed thro more than seventy editions. He was, in fact, preparing the material for a new edition of this book when, upon rising from his chair, he fell and sustained injuries and shock which resulted in his death the following day.

To the City of New York he gave much of his time and energy. From 1855 to 1858 he was a member of the City Board of Councilmen and was the presiding officer of that body during the last year of his service. He also acted as a member of numerous important and responsible commissions. While his professional activities were necessarily limited during his later years, he was from 1898 until the day of his death Consulting Engineer to the Board of Public Improvements and the Board of Estimate and Apportionment, and when his death was announced the Mayor of the city paid tribute to his long and conspicuous service in a special message to the Board of Aldermen.

Mr. Haswell's reputation was not confined to his own country. Fifty years or more ago the Czar of Russia presented to him a ring with an expression of thanks for services rendered to the Imperial Government. Among British engineers and naval architects he was well known and highly honored, and at the time of the visit of the Institution of Civil Engineers of Great Britain to this country in 1904 they showed him markt attention and honor.

His personal qualities were as winning and admirable as his professional accomplishments were notable. Refined in thought and taste, dignified and always curteous in bearing, charmingly interesting in reminiscence and anecdote, he was exceedingly modest and reluctant to speak of his own achievements. He was an admirable example of the old-fashioned courtly gentleman of the type which is becoming all too rare.

Mr. Haswell was one of the few Honorary Members of the American Society of Civil Engineers, and was also a member of the

following organizations: The British Institution of Civil Engineers, The Institution of Naval Engineers of Great Britain, The Naval Engineers of the United States, The American Institute of Architects, The New York Academy of Science, The New York Microscopical Society, The Society of Authors, The Engineers' Club of New York, The Engineers' Club of Philadelphia, The Union Club of New York City.

MESSAGE FROM HIS HONOR THE MAYOR.

City of New York—Office of the Mayor,
May 14, 1907.

To the Honorable the Board of Aldermen of The City of New York:

GENTLEMEN—In the death of Charles Haynes Haswell, for nearly thirty years a faithful, earnest and energetic servant of The City of New York, and for many years prior to that an engineering officer in the United States Navy, we have sustained a loss which it is my painful duty to call to the attention of your Honorable Board.

Mr. Haswell was born in this City in 1809, and would have reached the age of ninety-eight on the 22d day of this month. He was appointed a United States Naval Engineer in 1836, was Chief Engineer in 1845, a rank which he held until 1851, and during which time he brought our early steam navy to the highest point of efficiency in its history.

Mr. Haswell's services to the City are almost as conspicuous as his services to the national government. He died as a result of an accident at a time when, in spite of his advanced age, he was in full possession of his faculties, and was one of the City's most valuable servants.

He was the oldest civil employee in this country, if not in the world. He was the only living man who cruised on the "Clermont," and had planned to take an active part in the Hudson-Fulton celebration of 1909.

The unexpected ending to this most useful life is a matter which I bring to the notice of your Honorable Board for such action as you may deem fitting.

Yours respectfully,
GEO. B. MCCLELLAN, Mayor.

GEORGE JOHN HENRY MULLER.

George John Henry Muller was born in New York City in 1879. He obtained the degree of B. S. from Cooper Union. He entered the city's employ in November, 1904, as topografical draftsman,

in the Department of Taxes and Assessments. Previous to this he had been draftsman with Milliken Brothers, the Western Electric Company and the Engineering Department of the New York Telefone Company. He was elected a member of this Society May 22, 1907, and died during the summer of 1907.

ALEXANDER NAGY.

Alexander Nagy, charter member of the Municipal Engineers of the City of New York, member of Cooper Union Alumni Association, was born in January, 1869, in Hodmezö-Vásárhely, Hungary. In 1884 he was a fifth-year student of the Reformed Church Gymnasium (high school) in his native town, when, with his parents, he came to New York City. In the year 1886 he enrolled as a student of Cooper Institute, Scientific Branch. Having completed his studies at Cooper Institute in 1891, received the Cooper medal and "degree of Bachelor of Science." After graduating from Cooper Institute he went to Europe to complete his education, and enrolled in the Royal Hungarian University, Engineering Department, at Budapest, for the term 1891-1892.

Upon his return to the United States he was engaged by private engineering firms on various kinds of engineering works.

In 1893 he entered the Civil Service of the City of New York with the Department of Street Improvements, Twenty-third and Twenty-fourth Wards, where his services, both on field and office work, were appreciated, and was soon appointed as computer. After ten years of faithful service in the Topografical Bureau of the Boro of The Bronx, received an offer of appointment from the Boro of Queens, which he accepted. He had not been long in Queens Boro when again he was offered a position as computer from Richmond Boro. Here also he rendered invaluable service in the computing division of the Topografical Department, and was soon promoted to the position of assistant engineer.

The conscientious and efficient services rendered by him as computer on triangulation, damage-work, traverse, etc., in connection with the development of the street systems of the Boros of The Bronx, Queens and Richmond, have been well recognized in personal letters from his superiors.

In 1903 he received the "degree of Civil Engineer (C. E.)" at Cooper Union.

In the fall of 1906 his health commenced to fail, and the following spring he took passage to Europe to recuperate. During the sea voyage, however, his health failed him to such an extent that he was unable to continue the journey overland without assistance. After a few months of illness in his native town, he passed away on the 6th of July, 1907.

GUIDO DE ANGELIS.

Guido de Angelis was born in Naples, Italy, February 17, 1883. His father, Guido de Angelis, Sr., was a civil engineer, and the son began engineering work with his father at an early age. In 1902 he entered the employ of the Title Guarantee and Trust Company as transitman, and remained with that company, making surveys and looking after construction work, until August, 1904, when he resigned to accept the position of rodman with the New York Rapid Transit Railroad Commission. Here he was engaged on the construction of the Fort George tunnel.

In January, 1905, he was appointed transitman in the Topographical Bureau, Boro of Queens, and remained there until his death, which occurred by drowning in Long Iland Sound in the summer of 1907. He was elected a member of this Society November 22, 1905.

AWARD OF PRIZES.

These papers will be found in Proceedings for the years indicated.

1903.

JAMES COPPER BAYLES, M. E., Ph. D., for paper entitled: The Problem of the Maintenance of Asphalt Pavements in Manhattan.

1904.

GEORGE WILLIAM TILLSON, C. E., M. Am. Soc. C. E., for paper entitled: The Maintenance and Repairs of Asphalt Pavements.

1905.

SIDNEY WILLETT HOAG, Jr., B. S., M. Am. Soc. C. E., for paper entitled: The Dock Department and the New York Docks.

1906.

ALFRED DOUGLAS FLINN, S. B., M. Am. Soc. C. E., for paper entitled: The Organization of an Engineering Force in New York City.

PAST PRESIDENT MEDALS.

NELSON PETER LEWIS	1903-4
SAMUEL CLARENCE THOMPSON	1905
GEORGE WILLIAM TILLSON	1906
GEORGE STAPLES RICE	1907

INFORMATION.

MEETINGS.—Regular meetings are held in the Engineering Societies Building, No. 29 West 39th Street, Manhattan, on the fourth Wednesday of each month at 8:15 P. M., except in June, July and August. The Annual Meeting is held on the fourth Wednesday in January.

LIBRARY.—The Society rooms and library are open every day and evening, including Sundays and holidays.

Members of the Society and all who feel an interest in the maintenance of a technical reference library, devoted more especially to the subject of municipal engineering, are asked to donate engineering books, reports, specifications, maps, plans, and fotografs.

PROCEDINGS.— The Society issues one volume of PROCEDINGS each year, usually in May. It contains all of the papers presented during the preceding year, the annual address of the President, the final reports of special committees on professional subjects, descriptions of the works visited by the Society, and the speeches delivered at the annual banquet which are of permanent value.

Procedings are furnished without extra charge to members and are sold for $2.00 in cloth and $1.50 in paper. Exchanges are desired with other societies, libraries, colleges, etc.

PAPERS.—Papers and discussions on subjects of engineering interest are invited from all persons, whether members of the Society or not. They are, of course, subject to proper editorial supervision. All papers on their acceptance become the property of the Society.

BADGES.—The badge of the Society is of gold with blue enamel in the design shown on the half-title of this book. It has a number engraved upon the back and may be obtained as a pin, a watch charm, or a button. The price is $4.00. Application for it should be made to the Secretary.

CERTIFICATES OF MEMBERSHIP.—The certificate of membership is steel-engraved on parchment paper, engrossed with the name of the member and the date of his election; the seal of the Society is imprest and it is signed by the President and Secretary. The size is 14 by 18 inches, and the price is $2.00. Application for it should be made to the Secretary.

REMITTANCES.—All remittances should be made payable to the order of Municipal Engineers. They should be made by check on New York or by post-office or express money order payable at New York.

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EDMUND J. MAURER	1908-9-10
EDWIN J. FORT	1908-9-10

BLACKWELL'S ILAND BRIDGE.

INSPECTED BY THE SOCIETY APRIL 27, 1907.

This bridge, at the time of inspection, was in process of construction by the Pennsylvania Steel Company, of Steelton, Pa. All the main members of the bridge were erected in the span over the Iland and in the cantilever arm from the Iland to the center of the easterly branch of the East River. The arm, reaching westerly from the Iland, was in process of erection and nearly completed. The steel towers rising two hundred feet above the masonry piers from the tops of which is to be suspended the entire bridge structure was a special feature of interest, as well as the rockers at the end of the completed cantilever, which will eventually connect at their lower end with the adjoining cantilever from the Queens side of the river. Among other things which struck the visiting members with surprize were single members 104 ft. long, weighing nearly 80 tons and the steel castings in the towers weighing nearly 45 tons each; also the large travelers 120 ft. high and weighing 625 tons when fully rigged. There were in the neighborhood of one hundred members of the Society present at this inspection, and everything was done by the contractors to make the excursion an enjoyable and instructiv one.

BROOKLYN ANCHORAGE OF THE MANHATTAN BRIDGE.

INSPECTED BY THE SOCIETY MAY 25, 1907.

A large representation of the Society was present at this, the second inspection trip of the year. This anchorage was of cyclopean masonry, Tomkins Cove limestone being used in the concrete. The structure is faced with cut granit and its estimated cost is $1 200 000, which is slightly more than the cost of the anchorage on the Manhattan side. The contract for this work has been given to the Kosmos Engineering Company, which has an elaborate plant operated by electricity. The bridge, whose terminus will be at Bridge and Nassau Streets, will be carried by four cables, each

22 in. in diameter, each cable consisting of 9 400 steel wires about ⅛ in. in diameter. The cables are to be attacht to the anchorage bars, which are to be held by 48-in. steel girders, 25 ft. long, placed at right angles to the bars and the whole surrounded by limestone concrete. The cables, resting in saddles on the tops of the steel towers, will be immovable, the expansion and contraction being taken up by the bending of the towers themselves. The bridge will be 160 ft. wide over all with a driveway in the middle, and flankt on each side with railroad tracks and promenades. The contract for the steel has been let to Ryan and Parker for $6 500 000. It is thought that the bridge will be open for traffic in 1912. The Chief Engineer is C. M. Ingersoll, M. Am. Soc. C. E., and H. D. Robinson, Assoc. M. Am. Soc. C. E., is the Engineer in charge of both the Manhattan and Brooklyn anchorages. Mr. W. R. Bascome, Assoc. M. Am. Soc. C. E., who is in direct charge of the Brooklyn anchorage, met the party and curteously explained the many details connected with the work.

RIVERSIDE DRIVE EXTENSION.

INSPECTED BY THE SOCIETY JUNE 22, 1907.

About eighty members of the Society met at the Claremont Hotel as guests of Mr. F. Stewart Williamson, Consulting Engineer for the Riverside Drive Extension. After luncheon, the party, under the personal direction of Mr. Williamson, and Mr. C. D. Bryden, Resident Engineer, made an inspection of the work in progress. The driveway, at an elevation of 75 to 80 ft. above the Hudson River, has a width of about 60 ft., sometimes breaking into two driveways with parkways between. The driveway foundation is of hard quarry stone 8 to 10 in. deep, hand set and carefully wedged, with macadam on top. At One Hundred and Thirty-fifth Street is a massive granit retaining wall over 70 ft. high resting on a pile foundation and faced with granit ashlar, relieved at the corners with quoins of hammer drest stone. Thruout this work Portland cement was used. The driveway at One Hundred and Thirty-eighth Street is carried over the street by an elliptical arch, having a span of 50 ft. and a rise of 12 ft. 6 in. This arch is made

of concrete and expanded metal faced at both ends with drest granit. A feature of the bridge over One Hundred and Forty-fifth Street is that at the east end it is an elliptical arch and at the west end a semi-circular arch. At One Hundred and Forty-eighth Street there was in construction what is to be known as the "Cascade." It is a series of playing and drinking fountains, small waterfalls and ornamental masonry. Between One Hundred and Fifty-third and One Hundred and Fifty-fifth Streets, owing to the fact that Trinity Cemetery is on the line of the extension, it was found necessary to erect a cantilever viaduct over the tracks of the New York Central Railroad at an elevation of 60 ft. above the tracks so as to give a width of 100 ft. for a driveway and sidewalks. This viaduct is about 700 ft. long, with its drives and walks carried on steel platform. The work now under construction extends from One Hundred and Thirty-fifth to One Hundred and Fifty-eighth Street along the banks of the Hudson River for about a distance of 1¼ miles, and the cost, exclusiv of land, is estimated at about $4 000-000. The contractors for the present work are the Ryan and Parker Construction Company and J. C. Rodgers. The work is being carried out from the designs and under the supervision of Mr. Williamson.

PUBLIC SERVICE TUNNEL.

INSPECTED BY THE SOCIETY OCTOBER 26, 1907.

A large number of the membership of the Society visited the Public Service Tunnel connecting the Battery at the Manhattan end with Joralemon Street on the Brooklyn shore. This tunnel was bilt under the direction of Mr. George S. Rice, Chief Engineer of the Rapid Transit Commission and President of this Society for the year 1907. The tunnel under the East River, from South Ferry, Manhattan, to Joralemon Street, Brooklyn, is part of the Brooklyn extension of the original subway in Manhattan and is known as Contract No. 2. The contract for the construction was let by the City to the Rapid Transit Subway Construction Company's general contractor September 11, 1902. The tunnel section was later sub-

let to the New York Tunnel Company, and work was still in progress, altho nearly finisht, at the time of the excursion.

ROUTE.

Beginning at a point in Battery Park near South Ferry about 400 ft. from the bulkhead line, the line of the tunnel runs under the ferry houses, crosses the river to the foot of Joralemon Street, Brooklyn, and continues up Joralemon Street as far as Clinton Street, a total distance of 6 790 ft. In turning from the river on the Brooklyn side to take the direction of Joralemon Street the tunnel line is on a curve of 4 500 ft. radius thru an arc of about 27 degrees. The grade is 3.1% downward on each side of the river except for a short distance near the middle where the grade is ½ per cent. This portion is joined to the steeper grades on each side by vertical curves of 10 000 ft. radius. The tunnel is everywhere below water level, except for 700 ft. at the Brooklyn end. The lowest point reacht by the tunnel is 94 ft. below mean high water.

GENERAL DESCRIPTION.

The tunnel consists of two circular single track tubes of the usual cast iron ring construction. They are 15 ft. 6 in. internal diameter, and run side by side 28 ft. apart on centers, except under Joralemon Street where this distance is decreast to 26 ft. The tubes are lined thruout with concrete and are grouted externally.

MATERIAL.

The material on the Manhattan side from the shaft east to the lowest point of the tunnel, a distance of about 2 700 ft., consisted almost entirely of rock. About half way from the low point to the Brooklyn side another stretch of rock, about 400 ft. in length, was passed thru. This formation is supposed to be continuous with Coenties Reef further north. The rock was generally found to be a good character of mica schist or gneiss, and except in places where the rock covering was slight or lacking no timbering was required. For the remaining distance the material consisted generally of sand of varying degrees of fineness. Under Joralemon Street and part-way out in the slip between piers 17 and 18 the sand

was of ordinary coarseness and contained considerable gravel, cobbles and boulders of all sizes. Between the two rock formations and east of the Brooklyn reef the sand was found to be extremely fine and often contained a certain mixture of clay. This material is of the same nature as the quicksand encountered in foundations in the lower part of Manhattan Iland, and shows a similar markt tendency to run whenever distributed.

SHAFTS AND HEADINGS.

Excavation for the Manhattan shaft, located in the Battery Park enclosure opposite South Ferry, began March 4, 1903. The shaft measures 14 ft. by 52 ft. in plan, taking in the headings of both tubes, and extends to the tunnel sub-grade, about 45 ft. below the surface. It is sheeted on all sides with 5 in. tunged and grooved sheeting driven to the rock line, which was reacht approximately half way down. The shaft is equipt with two lifts, one for each heading, operated by a single-drum hoisting engine with a continuous cable. Tunnel spoil is hoisted to the surface, run out on a trestle leading to a dock west of the U. S. Barge office, and there dumpt into scows. The headings for the north and south tubes were started east from the Manhattan shaft on April 9 and April 16, 1903, respectivly. By the end of May, 1906, the headings reacht a point near the end of the rock formation where further progress was stopt temporarily to install shields. In September the advance was resumed with the new shields. The first Brooklyn shafts, one for each tube, were located in Joralemon Street about 1 300 ft. inland from the river, just west of Henry Street, and about 700 ft. from the end of the tunnel section. Excavation of the south shaft began April 16, 1903, and for the north shaft June 10, 1903. They were each 20 ft. by 24 ft. in plan, sheeted with 4 in. tunged and grooved sheeting, and extended 65 ft. below the surface to the bottom of the tunnel. The first portion of the tunnel to be bilt in Brooklyn was the length of about 700 ft. in each tube east from the shafts to the end of the section. The shield for the south tube started eastward July 10, 1903, and reacht the end of the section January 11, 1904. The shield for the north tube started eastward September 13, 1903, and reacht the end of the section January 16, 1904. The shields for the west headings

were being equipt while the first pair progrest eastward. The south shield began the advance westward from the shaft November 12, 1903, and the north shield February 2, 1904. After the bulkhead line was past, caissons were sunk for the new shafts just west of Furman Street, and these were put into use in April, 1905, while the original shafts were filled up. The new shafts each measures 9 ft. by 13 ft. in plan, and were sunk 30 ft. below the surface to the top of the tubes, to which they were then connected. The final meeting between the headings took place between the two rock formations under the river. The north shields met December 14, 1906, and the south shields on March 1, 1907. They were then dismantled, leaving the outer shells in place, after which the cast iron lining was completed. Material removed from the tunnel thru the Furman and Henry Streets shafts was hoisted to the surface by means of a lift, with which each shaft was provided, dumpt into overhead bins discharging at the bottom into carts to be teamed away.

Tunneling Methods.

All tunneling operations were carried on in comprest air, except in the Brooklyn headings east of the Henry Street shafts, where the tubes are above water level, and inside the bulkhead line at South Ferry, where the leakage could be easily controlled by pumping. The working pressure varied from a few pounds to a maximum of 42 lbs. to the square inch above atmospheric pressure at the deepest section under the middle of the river. The tubes were divided into working chambers by brick or concrete bulkheads at intervals, into each of which were bilt two locks for passage of workman and materials. In the soft material the tunneling was by shield, under the protection of which the cast iron lining was erected. There were six shields, one for each of the four headings from the Henry Street shafts and one in each of the Manhattan headings, which were set up in shield chambers when these headings had reacht the end of the rock formation. Enough material was removed at one time to permit the shield to be forced ahead by hydraulic pressure so that one ring could be erected, after which the operation was repeated. Breast boards were used against the face where the material showed a tendency to run or slough off. In the fine sand a water jet was used to soften the material in the lower part of the face, permitting

it to be blown out of the working chamber thru a discharge pipe by the tunnel pressure. On the Manhattan side, where the material was rock, excavation was made in two stages by the ordinary top heading and bench method. Where the rock was of good quality and sufficiently thick overhead no roof timbering was necessary and the heading was carried a considerable distance ahead of the bench. Otherwise roof timbering was resorted to. This consisted of 12 in. by 14 in. timber arch sets in three segments at intervals of about 5 ft., with 3-in. lagging running lengthwise over top and sides. Where the shields encountered rock on the Brooklyn side they were slid thru it, while the excavation was carried well ahead of the shield wherever possible by a bottom heading. The overhang was then drilled and blasted down from the shield as it advanced.

SHIELDS.

The shields were cylindrical, 16 ft. 11¼ in. metal. The shields were divided into two main portions, front and back, by a transverse diafram of 3/8 in. metal, with openings thru which materials could be past. The front portion was reinforced to form a cutting edge, while the rear portion formed the protection under which the lining was erected. The front portion was divided into two compartments, an upper and a lower, by a horizontal platform, which projected 4 ft. beyond the cutting edge and was supported by inclined channel braces to the bottom. An extension was attacht to the upper portion of the cutting edge to form a hood, projecting 3 ft. 6 in., and this was similarly braced down to the platform. An interior shell, between the diafram and the cutting edge, formed an annular space within which the hydraulic jacks bore. There were 14 of these jacks, each 18 in. in diameter, around the circumference, reacting against the cast iron lining, and capable of exerting a total pressure of 1 400 tons on the shield at a hydraulic intensity of 3 000 lb. per sq. in. The pump supplying the hydraulic pressure to the jacks was mounted on a platform following the shield, this platform resting on removable roller brackets attacht to the flanges of the lining. An arrangement of valves was provided for cutting out any or all of the jacks. The shields were designed by Mr. Walton I. Aims, engineer for the sub-contractors.

Cast Iron Lining.

The tunnel shell is bilt up of flanged cast iron plates bolted together by their flanges to form rings, each composed of 8 segments and a key. The rings are 15 ft. 6 in. internal diameter, 22 in. in length, 1⅛ in. minimum thickness of metal, and 7 in. to 7½ in. depth over flanges. All abutting surfaces are planed, the segments are bolted to the adjoining ones in the same ring with three 1 in. bolts, and the rings are bolted to each other with forty-nine 1 in. bolts in the circumferential flanges. The weight of the ring varies according to location; the lighter ones, weighing 7 319 lb. each, being used in rock and above the water level in Brooklyn, and the heavier ones, weighing 8 332 lb. and 9 410 lb. each, being used under the river and for the rest of the work. Many of the segments, both of the light and heavy sections, crackt under the strains they were subjected to during construction, and these were removed if practicable, or if not they were reinforced later with steel rods embedded in concrete. The cast iron segments were lifted and swung into position for bolting up by means of a counterweighted radial arm attacht to the platform behind the shield and operated by a small air engin mounted on the platform. Where the tunnel was in rock and there was no shield the same arrangement was used and the lining kept generally close to the bench. As the lining was erected it was grouted externally thru a 1⅛ in. top hole in each segment, closed with a plug. In the rock the space outside the lining was hand-packed with stone spalls before being grouted, and the grout was confined in sections by concrete bulkheads or dams bilt in this space at intervals. The grout consisted of equal parts of crusher dust and cement, fed in at the top and mixt in an enclosed cylinder with revolving paddles operated by a small air engin. When sufficiently mixt, air pressure was applied at the top and the grout was forced thru the plug holes and behind the lining by means of a connecting rubber hose. The lining was made watertight by calking with metallic lead in the recesses at the inner edges of the joints and grometting the bolts under the heads and nuts with a ring of hemp and red lead under a plate washer.

Reconstruction.

Deviations from the establisht grade were caused by the faulty control of the Brooklyn shields in many places between the Henry

Street shafts and the reef. These necessitated subsequent reconstruction of parts of the tunnel, especially in the north tube, to avoid too great an irregularity in the resulting grades, and this was successfully accomplisht without materially interfering with the regular work of finishing the tunnel. The method adopted was simple and consisted generally of removing the cast iron segments in the lower half of the tunnel section and replacing them with new segments, curved to an elliptical outline so as to give more interior space at the bottom. For a short stretch in each tube near Hicks Street, where the earliest and most markt variations occurred, the upper half of the tunnel lining was forced outward and upward by heavy hydraulic pressure sufficiently far into the surrounding soil to permit the construction of a new masonry roof, providing increast clearance. The total length of tunnel reconstructed is 2 919 ft., of which 1 957 ft. were in the north tube and 962 ft. in the south tube. The time occupied by the work was 13 months.

Piles Under Tubes.

The matter of the stability of the fine sand each side of the Brooklyn reef under the loads of moving trains having been questioned by officials of the Interborough Company, it was considered advisable by them to provide some auxiliary means of support, such as piles reaching to rock at intervals under the tubes where they past thru the material in question. This view was not concurred in by the city engineers, but as experiments showed that the piles might be driven rapidly without materially delaying completion, the work was allowed to proceed. In the midriver section between the Brooklyn reef and the Manhattan rock formation 17 concrete pile bents were sunk under the north tube and 15 under the south. Each bent consisted of 2 piles, about 20 in. in diameter, spaced 7 ft. apart transversely and about 30 ft. apart longitudinally of the tunnel. The piles were driven to depths ranging from 5 to 40 ft. In the fine sand formation east of the Brooklyn reef 15 similar pile bents were sunk in each of the tubes. The pile bents in this section were spaced about 50 ft. apart longitudinally, and extended to depths ranging from a few feet to 75 ft. In every case the piles were driven to hard material. To drive the piles it was necessary to remove the bottom plates of three rings below the spring line. The piles were then

forced down by hydraulic jacking in sections, with an outer steel casing filled with concrete, reinforced by four longitudinal rods. A 4-in. pipe ran thru the interior of the pile, and thru this pipe a smaller one jetted at the end. When a firm bearing was reacht the piles were connected at the top by a broad reinforced concrete cradle, and the cast-iron lining was replaced.

Concrete Lining.

After making the cast-iron lining watertight the air pressure was removed, and the interior of the shell lined with small stone concrete, mixed 1 : 3 : 4. At the bottom under the track the concrete is brought 8 in. inside the flanges and leveled at the ends of the ties to afford them a solid bearing. A concrete bench is bilt at each side of the track to enclose the seven single-way tile ducts in each bench for electric cables. At intervals of 300 ft. the duct bench is omitted for a space of 10 ft. to leave a chamber for splicing the cables, and these are to be covered with iron gratings. The concrete lining of the roof is brought flush with the inside of the flanges of the cast-iron lining wherever the tunnel is in rock, or under the land east of the bulkhead line in Brooklyn. For the remaining distance in soft material under the river the concrete lining is made sufficiently thick to cover the flanges 3 in. at the upper quarter points, and further increast in thickness at the crown and spring line on each side by making the outline flat at these places. In this additional concrete were embedded three circumferential 1¼-in. round rods per ring, extending over the top arc at 120°, and at the crown sixteen longitudinal 1¼-in. round rods in 18-ft. lengths connected by turn-buckles. In the bottom concrete over this same stretch were embedded a corresponding number and arrangement of circumferential and longitudinal rods. Lapping the circumferential rods at the top and bottom on each side are two 1-in. square rods per ring placed vertically. The whole reinforcement adds greatly to the resistance of the tunnel section to deformation. After the concrete lining was placed it was given a wash of cement grout as a finish to the surface.

Drainage.

Sumps for collecting the drainage of the tunnel are excavated in concrete-lined cross-passages between the tubes at three places

under the river. One sump is located at the low grade point near the end of the Manhattan rock formation; one about half way from there to the Manhattan shaft; and one in the Brooklyn reef. Each sump is to be equipt with a Cameron single-acting pump operated by comprest air, discharging thru two 6-in. cast iron drain pipes embedded in the concrete under the track in each tube, to the permanent shafts on each side of the river, from which points the water will be raised to the sewer by similar pumps of larger capacity.

VENTILATION.

There are two permanent shafts, one at South Ferry and one at Willow Place, Brooklyn, which are to serve as ventilating openings as well as connections for the drainage system and power cables. The working shaft at South Ferry was enlarged for this purpose, while the Willow Place shaft was a new one, excavated under air pressure and sealed to the outside of the tunnel shell. The shafts are lined with reinforced concrete, include both tubes of the tunnel, and measure about 14 ft. by 45 ft. inside in plan. The shafts are to be equipt with electrically operated fans and so arranged that the air may be moved in or out of either of the tubes. Under ordinary conditions it is expected that adequate ventilation will be obtained by the movement of air from the passage of trains thru the tubes.

TRACK.

The rails weigh 100 lb. per yd., and are spiked with tie plates to 6 in. by 8 in. yellow pine ties spaced 18 in. on centers. The ends of the ties bear on the concrete lining, and the spaces between their ends are to be filled with concrete flush with the top. The rest of the space between and under the ties is to be filled with 2-in. broken stone ballast.

COMPRESSOR PLANT.

The air supply for maintaining the pressure in the headings and operating drills, pumps, and hoists, was furnisht by a plant on each side of the river. In the early part of the work the plant proved inadequate for the necessary supply and had to be greatly increast. As a result there were considerable periods when only one tube could be worked at a time. The Manhattan plant, located in the enclosure at South Ferry, consisted of two large and two

small machines with a combined capacity of 10 000 cu. ft. free air per minute. The Brooklyn plant, located on Furman Street just north of the shafts, consisted of five large and five small machines with a combined capacity of 22 000 cu. ft. free air per minute.

COLUMBIA UNIVERSITY.

INSPECTED BY THE SOCIETY NOVEMBER 23D, 1907.

Through the curtesy of President Butler, of Columbia University, all the departments of that institution were thrown open to the members of the Society for their inspection, and, under the guidance of Prof. Fred. A. Goetze, Dean of the School of Applied Science, who met the visitors at the entrance to the Low Memorial Library, they were led to the college commons or dining hall, where luncheon was served. About 75 members of the Society were present. Immediately after luncheon the party was fotograft as they groupt themselves about the statue of "Alma Mater" on the Library steps. The members were then conducted thru the underground system of connecting heat and light condit tunnels, showing the ventilating and power plants and the gymnasium and swimming pool. The laboratory was then visited and the method of testing the strength of materials was interestingly shown by Prof. Woolson and his assistants. After a most interesting inspection here, the visitors were shown the methods of mine exploring and the testing and treatment of ore. The inspection closed with a visit to Hartley Hall Dormitory, St. Paul Chapel and the models of the New York Subway, Harlem River tunnel and the Panama Canal. Altogether this constituted one of the most interesting inspections in the history of the Society.

HUDSON COMPANY'S TUNNEL.

INSPECTED BY THE SOCIETY DECEMBER 21ST, 1907.

Thru the curtesy of Mr. Charles M. Jacobs, Chief Engineer of the Hudson Companies, about two hundred members of the Society were privileged to inspect the tunnels which the Companies have

bilt under the North River between Morton Street and Hoboken. This work embodies a portion of the old tunnel, which was begun as long ago as 1874, but was abandoned after several unsuccessful attempts to complete the connection between New York and New Jersey shores. The final and successful effort to finish the work was begun in 1902. The tunnels are now practically finisht and the electrical appliances are being installed. When the new Companies took charge in 1902 the north tunnel had been bilt nearly 4 000 ft. from the Jersey end. The shield used by the English Company was employed in this work, but with some modifications made necessary on account of approaching rock which had to be blasted out and the work made safe for the men at the same time. This was effected by means of an apron bilt in front of the shield and across its center line and under the protection of which the work of drilling and blasting was carried on with safety to the workmen. At times there were 65 ft. of water and not more than 14 ft. of a thin silt over the rock. It was often necessary to bank the river bed with clay to prevent loss of cover due to "blows." In the south tunnel important changes were made. Its diameter was reduced to 15 ft. 3 in. and the dimensions of the lining plates were also altered. The following is quoted from the descriptiv circular issued by the American Society of Mechanical Engineers after an inspection trip over this same work on the 12th of December:

"The tunnel makes connection with the several railroads on the New Jersey shore. The south tunnel of the old work was lowered so as to pass under the north tunnel at the shaft, thus avoiding grade crossing. The Hoboken terminal makes connections with the Delaware, Lackawanna and Western; connection is also made with the Erie ferry, and at the Pennsylvania station connection is made with the Cortlandt street tunnels, which are nearing completion."

"Three caissons were sunk at the switch points of the curves just west of the shaft. These caissons were the first of the kind ever bilt. When they were required steel could not be obtained within any reasonable time and wood was not desirable. Therefore reinforced concrete was adopted. This structure was found cheaper to bild and to serve the purpose much better than either steel or wood. Two of the caissons measured 105 by 46 by 23 ft. and at the shoe were 47 ft. 5 in. high. These caissons were in each case bilt on the

surface and sunk complete under air pressure to an elevation 85 ft. below tide. They weighed about 10 000 tons each and are double decked so as to allow the westbound tunnel to be superimposed on the eastbound, the wide end of the caisson allowing for switches to permit the trains to pass to the north or the south on each deck. Shields from the river entered the caisson at the narrow end and past thru the north side, while new shields were erected for the south side at the wide end. Difficulty was experienced in obtaining a foundation for the Hoboken terminal and it was necessary to introduce a system of inverts. The other station was formed by cutting away the adjacent sides of the tunnels, bilding a platform and throwing an arch between the two."

Mr. Jacobs and his deputy, Mr. Davies, accompanied by several of their assistants, personally accompanied the party and an exceedingly interesting afternoon was spent over the many points of interest. Those present are indebted to Mr. Jacobs for the enjoyment of an elaborate tho informal luncheon in the Hoboken terminal.

ANNUAL DINNER.

The Fifth Annual Dinner of the Society was held at Shanley's "Roman Court," January 7th, 1908. There were present 335 members and guests, a number so much in excess over that of preceding banquets, that the capacity of the hall was extended to the limit of elasticity. President George S. Rice acted as toastmaster and gracefully introduced the speakers.

Hon. HERMAN A. METZ, Controller of the City of New York, spoke of the difficulties besetting the financial officer of a metropolis, and made a plea for exempting only those bonds from the debt limit which produce an income and a sinking fund.

JOHN F. MURRAY, Commissioner of Public Works, Boro of Bronx, in behalf of Boro President Haffen, delivered the following graceful eulogy of the engineering profession:

It was my pleasure to be with you about a year ago and at that time also to represent the President of the Boro of The Bronx. I was given to understand by him to-day that he was expected to be a guest of yours to-night and to deliver an address. In view of the fact that for the past five days he has been ill at home, he has requested me to present his views to you this evening, not in the capacity of a Boro President, but as a Brother Engineer. I believe that he has the only distinction conferred upon any Boro President of the five Boros of Greater New York in being an Engineer, and he has the further distinction of having at the head of his bureaus Engineers of eminence, and appointing a Commissioner of Public Works with no experience whatever to tell the experienced men what to do. I am perfectly content, however, to say that in connection with the development of the boro and the admirable administration that I believe is being conducted there, that we have not at all interfered with the admirable management of the Engineers of the different bureaus of that boro. He desired me, therefore, to convey to you his sincere regrets for being unable to be present to-night, and begged me to assure you that the sentiments which are contained in his short address come from the bottom of his heart; and I assure you, on the other hand, that I desire personally to com-

pliment him upon the position which he takes so far as you Engineers are concerned. His address is as follows:

"Mr. Toastmaster and Fellow Guests and Engineers:

"I am here on the express condition that my part in the 'feast of reason and flow of soul' shall be very brief. The invitation with which I was honored proved your President and my dear friend, Mr. Rice, to be exceedingly kind and merciful in his regard for you. Without any indirection or beating about the bush I was admonished that I would be expected to say only a few words to my fellow Engineers on this gay and festiv occasion. The limitation is one I gratefully accept. Yet it would require many more than a few words to adequately voice my appreciation of the honor and curtesy you have extended to me by making me your guest, and to express the sincere pride in my profession which possesses me when I look around this banquet hall and note the number and the character of the men who, as Engineers, are rendering the City of New York the most valuable, the most unselfish, and by far the most important service its people receive from any branch of the Municipal Government.

"I recognize that the Society of Municipal Engineers represents the best traditions of the engineering profession, and therefore I rejoice at the remarkable success your organization has achieved. I cannot help but wish that this assemblage of trained and skilled men could be seen by those carping critics who claim to believe that the public service of the City of New York is a vast refuge for the idle, the illiterate, and the incompetent. Their constitutional narrowness and spirit of malice might not be mitigated, but they certainly would be convicted of forever after speaking against the light.

"I am aware that this is one of the occasions when those of us who are Engineers are expected to refrain from talking shop. Nevertheless, I am going to speak my mind and say that nowhere in the United States,—and I am not afraid to include any other country,—in governmental service or in private business, is there a body of men in any walk of life who bring to their daily vocation more of honesty, skill and efficiency, or a higher conception of duty, than the Municipal Engineers of the City of New York. If their salaries were proportionate to the real value of the services they render, it

would require a special edition of the *City Record* to print the list of salary increases, and Controller Metz would be compelled to find a market for a good-sized issue of revenue bonds to pay them.

"Some of us have constant and personal knowledge of the never-ceasing effort of a small but noisy and self-important element in our population to deceive the people into believing that their representatives and public officials find their conception of public duty in an atmosphere of wastefulness and inefficiency. Instead of serving a laudable and useful purpose by observing the truth and indulging in helpful criticism based on facts, these self-appointed censors of their fellow citizens judge all public men with prejudice and malice and charge officials with faults and shortcomings that exist only in the fervid imagination and envious mind of the slanderer. The truth is, and it can easily be demonstrated, that in the conception and consummation of the colossal public works which have made the City of New York one of the marvels of the world, there is a degree of honesty and efficiency far beyond the record of private enterprises of equal magnitude in any part of the world. The personnel of the City Civil Service can safely stand comparison with the personnel of the great business corporations that train and develop the high financiers and 'wealthy malefactors' about whom in these strenuous days we hear so much. More than one of us can say,—indeed, I am confident every one of the Engineers around these boards can say with absolute truth,—that the only reward we receive for our public service is a poverty almost equal to the poverty of the proverbial church mouse and a humility greater than that of the microbe. And this spirit of humility is renewed and deepened every time we read in our morning and evening paper the luminous opinions and heavy judgments of infallible journalists and superior citizens who substitute prejudice for information and slander for truth, and who see evil and incompetence everywhere except when they look in their own mirrors.

"The honest and conscientious public official, however, has little to fear. Patience he must exercise when he finds himself the target of deliberate misrepresentation and selfish intrigue. But we are told that patience is a virtue and that virtue is a jewel beyond price. Therefore the more patience he exercises the richer he will be,—and what greater reward can we ask or expect?

"Sooner or later the American sense of justice and instinct for fair play draws the line between the noisy, self-seeking pretender and the man of action whose honest deeds and righteous motivs constitute his entire and sufficient defense.

"Whether our place in the public service is of great or minor importance, neither misrepresentation nor calumny should turn us aside from what we know to be the path of duty. By example as well as by word and exhortation, we must do all we can to elevate the ideal of public morality and to make the badge of public office a badge of respect and honor. The Civil Service of the City of New York is replete with honest and capable men who discharge their duties with absolute loyalty to the highest principles of personal honor and public fidelity.

"Before I resume my seat, I must add to my congratulations on the success of this organization of Municipal Engineers a word of admonition, especially to the young men I see before me. The Twentieth Century, in which it is our good fortune to live, is pre-eminently the age of the Engineer. For more than a hundred years it has been said that the United States is the paradise of lawyers, and that the little of public honor and glory not appropriated by the lawyers belongs to the Colonels and Generals and Admirals of the Army and Navy. But no thoughtful man, surveying conditions as they exist and develop in our City and State and Nation, and in the world at large, can fail to arrive at the conclusion that the future belongs neither to the lawyer nor the warrior, nor the sea fighter, but to the men of applied science, the civil, mining, mechanical and electrical Engineers. As civilization widens and deepens, and men and nations in their mutual relations become more just, peaceful and law-abiding, war will cease, the lawyer will not find his vocation so extremely prominent and so mightily important, while the expert Engineer will enter into his own. If you look abroad, on every continent and in every country you see the scientist and the engineer laboring together to augment the world's wealth and to subdue and conquer the forbidding aspects of Mother Nature and render her subservient to the welfare and happiness of mankind. In Germany, France and Great Britain canals and enlarged waterways are projected that will result in enormous economic changes. In Japan, China and Australia a new world

is being called into existence by men of our profession. Africa, with her limitless hidden treasures and boundless wealth, is given over to the explorer, the scientist and the masters of engineering. By the construction in Egypt of the Assuan Dam and the Assuit water storage works, the fabled Nile of the Pharoahs has been converted into a river of blessings, and a triumph of engineering has saved a whole nation from calamity and distress. In our own country, stupendous engineering projects follow each other with such rapidity that we are no longer startled by any proposition, no matter how huge and costly it may be. New York owes to engineering science the fundamental factors which make her the Empire City of the Empire State. It was Clinton's ditch which in 1825 brought the lakes to the sea and ensured her commercial supremacy. The subways and tunnels, bridges and viaducts, elevated railroads and trunk line terminals completed and projected within the past two decades, amazing as they are, give us but a faint idea of what the future has in store. The wonderful engineering achievements in New York City since 1900, which cause the world to marvel, justify the personal and professional pride we feel in the great masters of our profession.

"The Croton Aqueduct has long been an old story. The Ashokan Dam and the 100-mile and $161 000 000 waterway from the Catskills to Manhattan is already a familiar tale, while the Panama Canal hardly excites more than the passing interest of the average man. In the State of New York the Erie Canal is being slowly but surely modernized, with potential results for the trade and commerce of our City as revolutionary and far-reaching as those which followed the original construction of the water-link that connected the unsalted seas of the North and West with the tides of the Atlantic Ocean.

"The lay mind is almost staggered by a mere contemplation of the engineering enterprises suggested for the next ten years within the United States. In the words of a newspaper writer, these great national projects 'come little short of providing a new earth, with incidental improvements in the conduct of the celestial bodies.' Not one of the colossal projects thus described is visionary or impossible of attainment. Our vast system of natural waterways is to be developt and co-related and made a hundredfold more effectiv by the widening and deepening of channels and the construction

of canal systems extending from the Great Lakes of the North to tide water at the Gulf. In the Far West the Columbia and the Sacramento are to be harnessed as Niagara to the uses of man. The tributaries of the Mississippi and the Missouri are to be converted into navigable streams. Irrigation schemes are to change millions of acres of arid plains into fertil lands that will blossom as the rose and afford happy homes for myriads of people. Great swamps are to be reclaimed by drainage; river waters to be clarified and conserved for the health and happiness of prosperous communities. Besides these mighty schemes involving our interior waterways, the gigantic railroad system of the nation is in process of rebilding. So that whether you look north, south, east or west, the surveying corps and staff of Engineers are everywhere in evidence, busy on their beneficent tasks of peaceful conquest.

"It is the most auspicious sign of the coming reign of universal peace and felicity that in every land men possest of the insight and foresight of Statesmen are asking whether it is not far better for mankind that the nations of the word shall cease to sacrifice human lives and to spend the substance of the people in war and on armaments and battleships, and instead shall encourage and stimulate the creation of new wealth and happiness by developing and utilizing to the very utmost degree the natural resources with which God has blessed the earth.

"Half a billion dollars expended for waterways and irrigation schemes and internal improvements in the United States will accomplish far more toward augmenting the glory and greatness of the nation and increasing the wealth and happiness of the people than a billion dollars spent on battleships and guns and powder, altho the latter may be necessary for some time to come to maintain the supremacy of our country. The day of war and blood is fast passing away and we are near the dawn of the better day of grand and noiseless triumphs of peace. That is why I assert with pride and confidence that in material things the future belongs not to the warrior on land or sea, but to the trained and expert Engineer. It especially behooves the young men in our profession to ever keep this fact before them. They should be inspired by a sense of the nobility of their profession. They must constantly develop in character and capacity. The great age we live in will

demand more and more from them as the high mission of the Twentieth Century gradually evolves and makes it clearer from year to year that the brutal and destructiv reign of the sword is at an end and that the peaceful and beneficent reign of the instruments, mechanisms and ingenuity of the men of applied science has just begun."

Hon. George Cromwell, President of the Boro of Richmond, congratulated the Society upon the success of the past and the hope of the future, and spoke feelingly of the unselfish civic patriotism which is so essential to the municipal engineer.

Hon. Henry S. Thompson, Commissioner of Public Works, Boro of Manhattan, spoke of the great difficulty of enforcing proper repair of streets as follows:

Few of the people of this City realize the extent of control which the Municipal Engineers exercise over the interior workings of the City government. Some people think the heads of Departments issue orders for work that has to be done and when finisht the Controller pays for the charge. They do not know before the order for the work is given that practically in every instance an Engineer has gone over it. So much of the work of the City is technical nowadays that Engineers are coming to occupy more important places every year, and for the work done and the responsibility assumed the pay is not in proportion. I can speak intelligently upon this as the head of a Department, and I know how much every Department head has to depend upon his Engineers. and that a hearty co-operation between the head of the Department and his Engineers makes more than anything else for the successful conduct of the work of a Department. I believe that such being the case and the Department head of necessity having to leave so much technical work to his Engineers, that it is the duty of such a Society as this to establish a standard of honesty among Engineers, so that if an Engineer is a member of this organization he will be known to be a man that can be relied upon, and if there is an Engineer working for the City who is not a member, the head of a Department will know he must ascertain the reason why. This, if worked out fairly, will be an excellent thing, but if worked unfairly would soon bring discredit upon such. I say this because complication is so apt to creep into everything connected with the

City. I think it would result in great good if the Engineers would have frequent meetings and arrange upon uniform plans, etc., for carrying on the work. Not only would the specifications be better, but the City would be benefited by not having the same thing done in half a dozen different ways. If the new Charter goes into effect, it will go a long way toward making this possible. In the last few months in the Department I have learned much, and for those of you who are not connected with the highways I thought it would be interesting to know what a serious problem confronts the City at present as regards the keeping of the streets of this City in repair.

I could say a great deal about the form of contracts and the different kinds of pavement, and question of adapting our pavements to the heavy and increasing traffic, but I know time will not permit me to go into all of these details, so I will only say a few words on the most important subjects at present, viz.: the keeping in repair of the present asphalted streets. I say asphalted streets because they constitute by far the largest proportion of paved streets.

The contracts entered into between the City and the Asphalt Companies provide that after the streets have been paved the Company must keep them in repair for a certain number of years, and in default of their making repairs when notified by the City, the contracts provide that the work may be done and charged against the Contractor and percentages retained by the City on the contract. This sounds very easy, but the fact of the matter is that there are practically only three Asphalt Companies doing business in New York City that have plants available for the laying of asphalt in this vicinity. The number of asphalted streets is now so great and the traffic is becoming so much heavier than anticipated, making the necessity for constant repairs greater, that all of the Asphalt Companies are always considerably behind in their work, and therefore it would be a foolish proposition to give an order to one Asphalt Company to do the work of another, when that Asphalt Company cannot keep up with its own work. You will therefore see that the most serious condition of affairs exists, viz.: that the City is practically in the clutches of the Asphalt Companies, which I have no dout have more or less of an understanding between them.

In addition to the above state of affairs, the City has, owing to the stringency of the money market, practically laid itself open for breach of contract for not paying the Asphalt Companies for what they are entitled to, and thus has given them the whip hand to do as much or as little work as they please. You can therefore see what a crying need this Boro has for the establishment of its own asphalt plant, and what an opportunity is presented for other Companies if we could only induce them to come to New York. We have little hope, however, of getting any new Companies to enter this field, when the asphalt supply made necessary by the specifications approved by the Board of Estimate and Apportionment practically rests in the hands of a single corporation.

I could go on and tell you about the great number of cuts and openings which are made annually in our pavements, enough, indeed, to keep an ordinary sized plant working overtime, but I think I have stated enough to show in what bad straits the City is in at the present time to enforce its demands and keep the streets of this busy City in repair. To show the condition of the City not providing for its own repairs this must be taken into account, viz.: the going into the hands of a Receiver of the New York City Railway Company. The New York City Railway Company has to keep the pavement between the tracks and 2 ft. either side in repair. To do this in many cases they made contracts with the different Asphalt Companies and they, of course, fear to do the work because the likelihood of getting paid is very meager, and the Receivers practically said that they do not care what becomes of the pavement. You no dout think the Asphalt Companies are more or less excusable for their failure to work and do not see why they don't stop entirely, and I must say, in all justice to the Asphalt Companies, they have done remarkably well in the face of the conditions existing this summer and fall. The only reason for keeping on with their work is that if they were to stop, the pavements would deteriorate so rapidly and get into such a wretched condition that the public would raise such a cry against asphalt pavements that they might be shut out altogether from future work.

As regards other forms of pavement, I believe that the past policy of the City has not been broad enough in allowing other

good pavements to be laid, even if they are patented. But the recent decision of the Court of Appeals in relation to patented pavements will help much in this matter. Other cities, especially those in the West, are far ahead of us in this respect.

I wish you Engineers of this Society would look into these matters about which I have spoken and devise some plan that would make for the betterment of our streets and arouse such interest that our present form of conducting the City government could be changed and be conducted on good, sound business methods. I think this Society, whose members are the ones most intimately connected with the practical and interior workings of the City Departments, should make the suggestions necessary. Your members are in every Department of the City Government and are therefore especially qualified to make suggestions and recommendations. And I say, in conclusion, that I believe in time that the different Bureaus in this Boro will have an Engineer as their executiv head.

MR. HERMON C. BUMPUS, Director of the American Museum of Natural History, made a plea for the establishment of a municipal museum, as follows:

It is true that a year ago there was discust before this organization the question of the establishment of some sort of a museum; a museum, as has just been stated, where documents and papers bearing upon the work of the Engineers of the City of New York might be deposited, where they might be consulted, where they might be properly classified so that consultation would be profitable. In discussing that matter with the Controller a little later it took a somewhat different form. It was thought that perhaps after all the essential point was that there should be some place where certain engineering problems before the City might be demonstrated for the benefit of the taxpayers of the City of New York. It is that particular phase of the subject that the American Museum has been somewhat interested in during the last twelve months.

There are a great many problems that are before you gentlemen about which the citizens of New York know very little. It has been remarked that even the Engineers of the different Departments before the organization of this Club or Society knew little of the work, the one of the other, but after this organization was formed the members of the various Bureaus became fairly well

acquainted with the work in the other Departments. If the Engineers in the City of New York are not acquainted with the work in the other Bureaus, why should the citizens be acquainted with the work of the Engineers at all? So that, as I am here imprest with the amount of energy that there is in this organization, I cannot help feeling that there is a waste of energy somewhere, because as you are working your work is not understood, and the by-product of that might take the form of some demonstration that would be of advantage to you and certainly of the utmost advantage to the citizens of New York.

There are several phases of this work that might be presented. There is the work of the various Departments. All cannot be done at once, but on consultation with Mr. Metz it was thought well that there might be an exhibit of the work of the Aqueduct Commission, the question of the supply of fresh water to the City of New York. There were no funds available, but the American Museum and some friends have taken an interest in this matter and with the limited funds which we have thus far, we have succeeded in making a number of relief maps that show the conditions of the water supply in the City at the time when the City extended no further north than Wall Street, with a statistical map attacht, and have also maps, etc., when the Municipal Water Supply was provided, when the City reacht a point about even with Canal Street; and again, a relief map which shows the condition at the beginning of the Eighteenth Century. A fourth relief map has been prepared, which runs up on the Hudson as far as Garrisons, and that relief map has been finisht within a week or two. The first model has been cast, and we now have a relief map that illustrates the condition at the time of the adoption of the Croton Aqueduct.

At the present moment it seems to me that we can do very little more than look into the future. There are not, I understand, funds available at present for the continuation of this work, but there is every indication—at least I firmly believe that there is every indication—that before long there will be sufficient substantial support to see this carried to a proper issue, viz.: the preparation of maps that will show the details of the present water-shed and of the proposed Catskill water-shed. These maps, when completed, will show in

sequence the history of the water supply of the City of New York, and form a skeleton exhibit to which, I hope, we can invite the citizens and in which you will take a growing interest.

ADDRESS OF MR. CALVIN TOMPKINS.

We are arriving at a very critical period in the history of the City. We have just completed the first tunnel under the East River to Long Iland; we have just completed the west tunnel to New Jersey, and within a very short time the trains will be running, carrying passengers east to Long Iland and west to New Jersey, and these two tunnels are but the commencement of many tunnels which will follow and which will enable the City to expand with equal facility east and west, as well as north and south. The importance of this I do not believe is fully recognized by the City generally, but you gentlemen can recognize the significance of the elimination of these natural boundaries of the Iland of Manhattan. Heretofore the City of New York has not been in a position to take advantage of its wonderful natural opportunities. The rivers on the east and on the west, which constitute the most magnificent harbor of the Atlantic Coast, have thus far really interfered with the development of the City. Now we are about to have all the commercial advantages of these rivers to make this City the great North American exchange point for commerce and we shall no longer be confined in our development by those two great tidal water belts, separating the central portion from the east and west. As a matter of fact, we have three great cities here to organize. We have the City in the center, the old City of New York (Manhattan), the Bronx to the north, on the east we have the Long Iland cities of Brooklyn and Queens, and in New Jersey we have that great City to the west, which is not and cannot be a political part of the City of New York, but commercially and economically it is an essential part thereof and this fact is recognized by the United States Government, which designates the Port of New York as including all of the local tributary waters,—of the Passaic and Hackensack valleys, as well as the Hudson valley.

The great problem which the cities of New York and New Jersey have before them at this time, and which you gentlemen particularly have the responsibility of properly solving, is the co-

ordination of these three great communities into the greatest city of the world. The City of New York is now only second in population to London and we are rapidly gaining upon London, so that within the lifetime of most of those here present, we shall have past that city in population and we shall have become, in fact, the greatest city in the world.

When we consider the improvements which the United States Government is making along the Ambrose Channel out to sea, so that 40-ft. draft vessels can be brought up to New York; when we consider the improvements that are being made in the Erie Canal, which will enable 1 000-ton barges to come thru that canal, where now only 200-ton barges pass thru, we perceive the great freighting facilities which will be added to the natural opportunities we now enjoy. We shall do away with the difficulties of intercommunication between our several sections, and we shall have the added opportunity to take full advantage of the level roadway from the Mississippi to the Atlantic seaport, thru the Mohawk and Hudson River valleys. When the canal improvements shall be completed, the railroads will not be able to maintain the same differential against the City of New York which they now do and New York will assume its final dominating position on the Atlantic seaboard of the North American Continent.

It is only within very recent times, within the last fifty years, that such great cities as the present New York, London, Paris, Berlin and Vienna have become possible, and they are made possible only by modern methods of transportation. It is now possible to feed the people in these great communities by bringing their food to them in steamships and by railroads, by bringing raw materials of manufacture to them and sending these transformed raw materials out. At these great points of concentration, labor is more productiv, and living conditions, if properly provided for, can be made much more advantageous than by scattering the population. It is an advantage to live in the cities and that is the reason people flock to them in preference to country residence. It is our business, particularly as Engineers, to see to it that the organization of cities is such as to make life there attractiv, and to provide conditions under which cities can compete with each other, and it is our particular business to see that the great natural opportunities of

New York City are utilized to the very fullest extent possible, so that it may become the most efficient factor of modern civilization in all the world. This means a very delicate balancing of forces. The City cannot be conducted now as it could have been fifty or a hundred years ago. We had some experience of the situation at the time of the blizzard some years ago, when there existed only a few days' actual supply of food in the City. Cities must be managed with technical ability and skill; they cannot much longer be managed in the old-fashioned political way. Any city that is so managed is naturally placed at a serious disadvantage in competition with cities which are better organized. For this purpose we should employ technical experts, as is the custom in European cities. Growth without congestion is the great problem. This means decent living; it primarily involves transportation, and we have with us as the head of this organization, the man who has so far been chiefly instrumental in solving that problem. The work done by the Rapid Transit Commission is the pioneer work in this direction and is the most interesting work connected with the future development of the City.

We have in New York another very difficult problem, which is peculiar to our City; that is, the problem of the streets. Transportation involves not only tunnel work, but it involves street facilities. The extensiv use of land in lower Manhattan—which is the objectiv point for the wholesale business for all of this great territory about Manhattan—is restricted by the East River on the one side and by the Hudson River on the other side. That makes necessary the most economical use possible of the ground. This is the reason for the existence of tall bildings. Tall bildings in the future will be more rather than less numerous in Manhattan.

The provision for light and air in the streets and obviating the conversion of the lower stories into mere cellars and basements, is the most vital problem. We have a street system designed for a five-story city, now being devoted to the uses of a twenty-story city. The street system is utterly inadequate; it must be thoroly reorganized in the older parts of the City—a most expensiv and difficult undertaking. At the entrance to the Blackwell's Iland Bridge you have the problem presented in its acute form now. Ten years ago it was just as evident as today that Fifty-ninth Street

would be utterly inadequate to carry the traffic which will come over that bridge. It is probably five times as expensiv now to get land as it was then, altho the necessity was just as evident then as now. It will be more expensiv to do so a few years hence, when it will become absolutely imperativ to act, on the completion of the bridge. Every administration we have had in New York City has shirked this particular problem on account of the expense. Some way must be found to adopt the street system of this City,—which involves the transportation system as well,—to the new requirements of the City. To my mind there is only one way by which this can be done. You can never bring about radical changes by reliance upon bond issues, based upon the income of the City derived from taxation. The only way we can meet this problem is to follow the precedents establisht in Berlin, in London, and in German cities generally; that is, by taking land in excess of what is needed for the particular improvement, at the valuation before the improvement is made, make the improvement and re-sell or release the abutting land subsequently at its enhanced value. A few years ago that suggestion would have been deemed irrational. It has now been formally sanctioned by the City Improvement Commission and by the Municipal Art Commission and is one of those reforms likely to be adopted in the near future. There is no Constitutional objection to such a scheme. The only difficulty that stands in the way is in obtaining legislativ sanction from Albany.

The exemption of revenue-producing bonds from the det limit to which the Controller has just referred, is also very essential. It seems absurd that just in proportion as the City acquires revenue-producing property, just in the same proportion its capacity for going into det is limited.

Another matter to which the Controller has called attention, is the necessity of having a comprehensiv plan of public improvements, well thought out in advance. If you have such a plan, improvements naturally take their place in sequence, in the relativ order of their necessity. Such an improvement determins of itself what should be done and what should be left to some more convenient time. At present we have no such co-ordinated system of public works laid out, and I know of nobody better equipt for leading public opinion in this matter than your organization. I

think the Municipal Engineers have a great opportunity here. It seems to me that just as the City is breaking away from its old leading strings, just in the same manner the engineering profession is about to expand and to take on new opportunities and new responsibilities. What I mean is this: Heretofore the province of the Engineer has been mainly to carry out the ideas and the orders of great corporations, looking for their pay in taking and executing the orders of the politicians who have heretofore governed the cities. Now, however, the time has arrived when good city government is becoming so important for the citizens and so many services are being taken on by the municipalities themselves, that we simply must, from the force of circumstances, provide in cities a much more efficient organization for carrying on their public works. And the same thing is true in the National Government. It is now suggested that we have a Bureau of Governmental Supervision over public waterways and highways and public works generally. This is inevitable, considering the immense expenditures which, of necessity, will be made in the near future by the general Government. Public work is of a distinctivly different character from private work, and the political conditions under which you gentlemen, in your profession, have heretofore worked, will change. The opportunity is now wider and the responsibility is greater, besides the responsibility is a public and not a private one in character, and it affords far greater liberty, far greater opportunity for wide-reaching influence than you could ever have had under the older system. It is important, I think, that this organization should, in some impersonal way, take advantage of that opportunity and speak not only with the authority of the individual Engineer, but that of the combined influence of the engineering profession in such a way as to make public opinion.

As a matter of fact, the Municipal Engineers are now—and I believe Controller Metz might possibly agree with me generally in the statement—the *de facto* government of the City of New York. The City is managed continuously from year to year, and from administration to administration, its public work is done principally by men in your profession. That is the way the cities in Europe are governed and most especially the German cities, which are the most admirably governed cities in the world. They are conducted

as great business enterprises by technical men, selected for their ability and maintained permanently in office. There is no such thing there as political government in the way we understand it here, and I think the influence of the engineers in the United States is now widening very rapidly in a similar direction. One evidence of that influence is the fact that you have so many governmental City Officials here with you tonight. I do not know of an occasion—certainly not the time I had the opportunity of dining with you three years ago—when I have seen so many representativs of the general City Government and of the several Boros. This indicates the drift of opinion. I notice the same sentiment, the same idea of the City's doing business thru technical men best able to do it, cropping out in the *Engineering News* and the best engineering publications thruout the country. I believe frequently the influence of the Society can, perhaps, best be exercised impersonally; in case the individual Engineers would not like to make comments, the Society itself could formulate its opinion thru a committee made up of men whose personal interests would not be affected. Heretofore this bilding up of public opinion has been done by organizations like the City Club, the Municipal Art Society, the Reform Club, the Chamber of Commerce, etc., but none of these possess the technical knowledge, the immediate personal touch and knowledge of the situation such as you gentlemen have. I think, on the whole, that you have been somewhat remiss heretofore in not making your influence felt as much as it might be, and, I am sure, gentlemen, that influence could be made more effectiv, as I have suggested, thru committees and thru representativs of your organization, in your Annual Report, etc. Nothing you can do would tend to bild up your own prestige, individually and collectivly, as effectivly as this would. What the City of New York needs at this time more than anything else, is public spirit; but, in addition, that public spirit should be guided by a correct appreciation of the problems which the City has to face. There is no city in the world with such possibilities and with such difficult problems to encounter as our City of New York, and you, gentlemen, are best equipt to state the case and to lay the foundation for a sound, clear-headed, right-minded public opinion, far more so than anybody else can. It is public opinion that finally determins these

things and not official, political opinion. If you develop public opinion in advance of carrying out any particular work, when the time comes to carry that work out the idea will already be there and the right method will follow. If, however, public opinion is not stirred and directed in the right channels in advance, when the time comes to act there are so many private interests to be encountered that it is very difficult to act rightly, and great friction is encountered in reaching the proper and right solution.

Lastly, gentlemen,—and this is my closing thought—in addition to the personal interest that you have in the practical question of a livelihood, it is a satisfaction to be able to practise your profession in New York City at such a critical and interesting development period—to participate in laying the foundations for a great historical city. It is a responsibility which should arouse enthusiasm as well as interest.

Mr. Robert Whitman Leslie, President of the American Cement Company, after some facetious engineering stories, gave high praise to the technical staff of the municipality for the excellence and economy of the works constructed under their supervision.

Mr. John Vipond Davies, of Jacobs & Davies, Consulting Engineers, calmed the Controller's financial fear by the following anecdote: An old German champagne salesman went to a customer of his, a prominent banker, who said to him: "What, buy champagne these times? I have no money with which to buy champagne. I cannot afford such luxuries now." "Oh, no," says he, "it is all right; it is not as tho you were bald; you've only had your hair cut; it will grow again."

Major Merritt H. Smith, Department Engineer of the Board of Water Supply, among other stories, related one illustrativ of the idea of economy prevailing in some cities (other than New York):

An Irishman who had been foreman of a track gang on a railroad was promoted to General Superintendent of this little railroad, and when he was promoted he adopted the suit of clothes that he thought was most appropriate to the dignity of the position he had to occupy, which was a Prince Albert, and called together the Track Foremen. "Boys," he says, "there's one thing I want you to remember as long as I have this job. There's one word, *one word*

I want you to remember, if you forgets nearly the whole of your mother tongue, and that word is *e-con-o-mee, e-con-o-mee.*" He gave them time and things seemed to go along all right, but one day he went out after trouble. He went out to a siding and got to the end; then he cut across lots to get to the main track again. As he went across lots he struck something hard and picking it up he found it was a railroad spike. He looked at it steadily and then started out for the nearest Track Foreman, found him and said, "Casey, have you forgot what I told you when I took this job? Did my words have little influence, after what I says to you? Why did you forget?" Casey says, "Mr. Grogan, I never forgot that speech; it was one of the greatest speeches I ever listened to. You told us there was one word, *one word* that you wanted us to remember, if we forgot nearly the whole of our mother tongue, and that word was e-con-o-mee, *e-con-o-mee.*" "Then, Mr. Casey," he says, "what does this mean?" and he held up the spike. "I found that nearly a hundred yards from the railroad right-of-way; what does that mean?" "Oh, Mr. Grogan, it's a schmart man ye are; where did ye find that? I had the whole d——— gang looking for that spike for four days."

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